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An Investigation of the Remediation of Learning Disabilities Based on Brain-Related Tasks as Measured by the Halstead-Reitan Neuropsychological Test Battery

Dana Stephens DeBoskey

To the Graduate Council:

I am submitting herewith a dissertation written by Dana Stephens DeBoskey entitled "An Investigation of the Remediation of Learning Disabilities Based on Brain-Related Tasks as Measured by the Halstead-Reitan Neuropsychological Test Battery." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Joel F. Lubar, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Vice Chancellor
Graduate Studies and Research

AN INVESTIGATION OF THE REMEDIATION OF LEARNING DISABILITIES BASED ON BRAIN-RELATED TASKS AS MEASURED BY THE HALSTEAD-REITAN NEUROPSYCHOLOGICAL TEST BATTERY

A Dissertation
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Doctor of Philosophy
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Dana Stephens DeBoskey

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ABSTRACT

This study involved thirteen learning disabled (LD) and ten normal Caucasian male children between the ages of nine and twelve. All children were evaluated pre and post with the WISC-R, WRAT, Bender Gestalt, Spache Diagnostic Reading Scale, Halstead-Reitan Neuropsychological Battery, and the spectral analysis EEG. Electrophysiological recordings of the EEG were recorded via eight bipolar pairs of electrodes placed at International 10-20 System positions, F_3-F_7, F_4-F_8, C_3-T_3, C_4T_4, O_1P_3, O_2, P_4, T_5-F_7, and T_6-F_8. Eight of the learning disabled children received instruction based on an individualized remediation technique utilizing the deficits of the neuropsychological testing. The intervention consisted of 32 sessions. If a neuropsychological remediation procedure would have positive results one would expect to observe changes in the neuropsychological, psychoeducational, and EEG data whereby the Treatment group would diverge from the measurements of the LD Control group and converge toward those of the Normal Control group.

Neuropsychological posttesting indicated that the scores for the treated LD group showed a general trend of improvement greater than for the two control groups but the differences were not statistically significant. The overall Selz and Reitan score (a general measure of neuropsychological functioning) was found to be significantly different for the treated LD group and the Normal Controls but not for the treated LD versus LD Controls.

The psychoeducational testing (WRAT, Spache, Bender) suggested that the remediation technique had the effect of increasing the academic performance of the Treatment group. The Treatment group showed significant gains in reading, spelling, arithmetic, and copying geometric designs in comparison to the LD and Normal Controls. This effect would be considered independent from maturation and would suggest that intervention of this type would be beneficial to the LD population.

Previous research has noted increased slow wave activity, increased beta, and alpha blocking during a task for LD children in general. Although in this study some of these were found in some locations, it appears that the small subject pool, the wide variation in subjects, and the presence of excessive EMG prevented the spectral EEG from yielding a clear diagnostic technique for rapidly screening LD students.

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INTRODUCTION

In 1963 Samuel Kirk introduced the term "learning disabled" and since that time there has been much confusion regarding who these children are. The label originally was to apply to those children who do not have abnormalities in intelligence, home environment, peripheral sensory defects, school environment, or emotional standing but who, for reasons unknown, have not been able to learn by the conventional school methods. There is often suspicion but not always confirmation of minimal neurological problems; nevertheless, the term minimal brain dysfunction (MBD) is often used interchangeably with LD (learning disability) where under-achievement in one or more particular academic area can be as high as 20-40% of the school population. The percentage that are truly learning disabled are 1 to 2%.

There is no consensus regarding which children fall into the various labels of MBD, LD, hyperkinesis, etc. A study by Silver (1975) exemplifies the overlap of these categories. He found the following in his study of 300 children:

1. 38% of the LD were also hyperactive,
2. 94% of the hyperkinetic had learning or language problems,
3. 30% of the emotionally disturbed had learning or language problems.

Where Silver emphasizes the overlap in these children, others such as Lahey, Stempniak, Robinson, and Tyroler (1978) have in a factor analysis found LD and hyperkinesis to be relatively independent of one another.

Diagnosis of learning disabled children can be approached from either a medical, psychological, or educational viewpoint or most appropriately a team approach using all of these methods. The physician looks for what are called in the literature "soft signs" of neurological difficulties; some of these are listed as follows:

1. awkwardness of movement,
2. visual or auditory perceptual problems,
3. poor fine motor coordination,
4. incomplete knowledge of body laterality,
5. directional confusion,
6. difficulty with body image,
7. speech defects,
8. concentration problems,
9. poor impulse control.

The school or clinical psychologist utilizes a battery of tests that have proven helpful in diagnosing learning disabilities. The intelligence test that has been widely used is the Wechsler Intelligence Scale for Children-Revised (WISC-R). The subdivision of verbal and performance subtests has provided clues to variation in performance of the two cerebral hemispheres of the brain. Tests revealing left hemisphere problems are those that investigate the language functioning of the child including abstract reasoning and social comprehension. Tests revealing right hemisphere problems are those that look at the fine motor coordination as well as spatial and visual organization. The Bender Gestalt designs as well as free hand drawings of people and objects are utilized here. Although this traditional battery of Wechsler, Bender, HFD (Human Figure Drawings), HTP (House-Tree-Person), and various visual memory tests has been helpful in diagnosing learning disabilities, Klonoff and Low (1974) as well as other researchers have shown that the Halstead-Reitan Neuropsychological Test for adolescents and children is more precise in determining neurological dysfunction than this typical psychological battery. Thus, the use of this test, although it requires approximately four hours to administer, can greatly increase not only the accuracy of substantiating the presence of neurological problems but can also help to delineate the major cerebral hemisphere involved. Recently Selz and Reitan (1979) have devised a scoring system for the Reitan Battery that helps to differentiate among normal control children, learning disabled children, and brain-damaged children. Normals score between 0 and 19, LDs score between 20 and 35 and brain-damaged score above 35. The brain-damaged children in this study had cerebral anomolies that had been substantiated by a neurologist.

The third group, the educational specialists, utilize the findings of the psychologist but they also have their own battery of tests, both formal and informal, that they use to diagnose learning disabilities. There is such a wide range of problems that no single test is sufficient. A partial list of possible academic problems are as follows:

1. reading 2 or more years below grade level (dyslexia),
2. problems with mathematical calculations (dyscalculia),
3. difficulty with spelling,
4. poor handwriting (dysgraphia),
5. problems with language (aphasia or anomia),
6. visual or auditory perceptual problems,
7. sequencing problems,

8. problems following directions,

9. directional problems.

Although these three orientations have been helpful in delineating learning disabled children, there are a number of researchers who are working to devise a more accurate and faster method utilizing electrophysiological measures. E. Roy John (1977), one of the most prominent of these researchers, develoed a Neurometric Battery (NB) which automatically analyzed data derived from scalp electrodes with a minicomputer. The recordings are not only automatically recorded but they are also compared with normative data stored in the computer. The recordings are those of the EEG (electroencephalogram) as well as the AEP (averaged evoked potentials). Both of these measures have been found useful in delineating LD children from normals.

Wechsler Profiles

A major barrier to inquiry into the nature of learning disabilities is the lack of reliable and valid instruments that will discriminate the learning disabled child from the larger school population and identify the child who fails academically for reasons other than learning disabilities. Investigators have examined the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949) and the WISC-R (Wechsler, 1974) subtest scaled scores for learning disabled children for a profile of psychoeducational diagnostic utility (Bannatyne, 1968, 1974; Rugel, 1974; Smith, 1978; Smith, Coleman, Dokecki & Davis, 1977a; Vance, Gaynor & Coleman, 1976).

Some researchers remain very optimistic and positive about the validity of the WISC-R as a diagnostic tool for diagnosing learning disabilities (Griffiths, 1977). However, many studies have been discouraging due to their failure to identify a clearcut pattern of WISC subtest scores (Ackerman, Peters & Dykman, 1971). Kender (1972) points out to conclude that disabled readers as a group make higher or lower scores on certain subtests relative to their performance on other subtests is misleading. Such an assumption might be more credible if each subtest could be interpreted as having a single implication for intellectual functioning. On the contrary, any given subtest has several such implications. To say, for example, that poor readers as a group score relatively low on the Arithmetic subtest is to overlook the child whose performance on that subtest is adequate but whose reading problem is as severe as a child whose Arithmetic score is below average. Thus, averages have their use in educational research, but when a teacher is concerned with diagnosis and remediation for an individual, group profiles are of little use.

In 1975 McCarthy and Elkins completed studies made in five different states to determine homogeneous clusters among learning disabled children. The results of their study suggested that those utilizing psychological testing need to be very cautious about the entire profile literature in which profiles of specific strengths and weaknesses on the WISC are said to be indicative of problems in academic achievement since they found no pattern on the WISC typical of the learning disabled. Evidence also showed that patterns on the WISC may vary among locales.

In reviewing the literature one has to be careful according to Vance et al. (1976) to note whether the authors utilize the WISC or WISC-R. Some investigators, e.g., Tanis and James Bryan (1975), suggest that interpretation of specific subtest functions of the WISC is of little use because of the unreliability of individual subtests. Matarazzo's (1972) findings indicate that after three decades of research on various forms of pattern analysis with the Wechsler Scales, little support has been found for their diagnostic use. However, Vance et al. (1976) believe that Kaufman (1975) has substantiated that with the WISC-R subtests there is an adequate degree of subtest specificity. Subtest specificity refers to the proposition of a subtest variance that is both reliable, i.e., not due to error of measurement, and distinctive to the subtest. Thus, they conclude that specific interpretation of subtest functions can be made for most of the WISC-R subtests.

There are four major methods researchers have used in approaching the question of a Wechsler profile for the learning disabled. Many researchers have addressed the issue of a significant difference between the overall Verbal and Performance IQ score. Some have focussed on the scatter of the subtests as well as documenting which particular subtests are above or below the score obtained by the normal functioning child. Others have gone beyond the individual scores and attempted to recategorize the subtests. Last, attempts have been made to formulate patterns utilizing a combination of the above characteristics.

Verbal IQ versus Performance IQ

Investigators have been interested in determining the correlates of Verbal-Performance discrepancies in learning disabled children. In one study of children between 9 and 14 years of age, a variety of achievement and perceptual tests were administered to three groups of learning disabled children (Rourke, Young & Flewelling, 1971). Their results showed that the P > V (Performance greater than Verbal) group performed significantly better than the V > P group on tasks involving visual-perceptual skills, whereas the V > P group performed significantly better on the tasks involving verbal and auditory perceptual abilities. There was no difference between the groups on tests of problem-solving ability. The investigators concluded that WISC Verbal-Performance discrepancies are useful in predicting differential performances on a variety of ability tests for children with learning disabilities.

In another study of 8-year-old children with academic difficulties (Wells, 1973), the P > V group in comparison with the V > P and V = P groups scored significantly lower on the Illinois Test of Psycholinguistic Abilities (Kirk & Kirk, 1971), and on the reading section of the Wide Range Achievement Test, whereas the V > P and V = P groups did not differ significantly on these two measures. Frostig Development Test of Visual Perception (Frostig, Maslow, Letever & Whitney, 1964) scores were not significantly different among the three groups. The findings of Wells, in part, corroborate those of Rourke et al. (1971). In general, the recent studies that have reported Verbal vs. Performance differences have noted that the overall Verbal IQ is lower than the Performance IQ (Anderson, Kaufman & Kaufman, 1976; Feeler, 1975; Smith, 1978).

Rice (1970) reviewed the clinical diagnostic findings of a multidisciplinary study of 100 learning disabled students divided into six categories between ages of 6-2 and 15-3. His evidence presented little support for the use of significant differences between Verbal and Performance IQ as a diagnostic indicator for learning disabled children. Thus, even though these differences are noted in the literature, it has been found that the Verbal vs. Performance dichotomy is not a practical diagnostic index for discriminating learning disabled children from other children (Kaufman, 1976; Vance et al., 1976; Vance & Singer, 1979).

Subtest Findings

There is a general belief among clinicians that the learning disabled profile is one that shows significant subtest scatter (Anderson et al., 1976; Tabachnick, 1979). When professionals are asked how much scatter is expected from the normal child, they typically respond with a range of no more than three to four points. However, Kaufman (1976) reported that it is typical for the normal child to demonstrate scatter with a mean range from six to seven difference points. The scaled score range for the Full Scale is as high as 7 ± 2 points. It is also pointed out that the level of overall intellectual ability affects the amount of scatter that is considered significant. Selz and Reitan (1979) take the overall IQ level into consideration in their formula for scoring the severity of the scatter by utilizing the following conversion measure: (largest subscale score - smallest subscale score) $\div$ mean of subscale scores. Scores above 1.41 are considered in the defective range. In his 1976 article Kaufman provides a number of tables for determining if a child's scatter is within normal range. Thus, more recent research has emphasized the overlap in subtest scatter between the normal and learning disabled populations (Miller, Stoneburner & Brecht, 1978; Tabachnick, 1979).

When looking at the individual subtest scores of learning disabled children, researchers report somewhat varied results although there is a great deal of similarity as well. This variance is not surprising when one considers the divergent categories of learning deficiencies. One would expect a child with a language disability to have the same subtest profile as a child with a severe visual-perception problem. However, in most of the literature little attempt is made to delineate the deficiencies when reporting subtest patterns. The most consistent finding across the board is a low score in Coding. This has led many diagnosticians to regard this subtest to be of singular diagnostic import (Reitan, 1979; Tabachnick, 1979). Rugel (1974) reviewed and summarized the findings of 25 investigators and concluded that the learning disabled profile included lowest mean scores on Arithmetic, Digit Span, and Coding. Highest scores were found on Object Assembly, Block Design, Picture Completion, and Picture Arrangement. Vance et al. (1976) report high scores in Object Assembly, Picture Completion, and Comprehension. Anderson et al. (1976) show high scores in Picture Completion and Comprehension with low scores in Information, Similarities, and Vocabulary. Two studies report identical low results in Arithmetic, Digit Span, and Coding (Ackerman, Dykman & Peters, 1976; Bradley, Battin & Sutter, 1979). More recently Milich and Lonly (1979) report high scores in Object Assembly and Similarities and low scores in Information, Coding, and Arithmetic while Tabachnick (1979) and Gordon (1978) report the well-documented low score in Coding with Tabachnick also showing deficiency in Digit Span. In general, one can see a great deal of consistency in results. The Similarities subtest is the only one that is reported to be relatively high in one study and low in another.

Recategorization

An early model of recategorization was presented by Money (1962). He determined three areas that included the following subtests: (1) the area of Perceptual Organization included Block Design and Object Assembly; (2) the area of Verbal Comprehension included Information, Comprehension, Similarities and Vocabulary; (3) the area of Freedom from Distractibility included Arithmetic and Digit Span. In this same year Witkin, Dyk, Faterson, Goodenough & Karp (1962) proposed that WISC subtests fall into three major skill areas that tap relatively independent functions. These skill areas were Verbal-Comprehension, composed of Information, Vocabulary, and Comprehension subtests; Analytic-Field-Approach, made up of Object Assembly, Block Design, and Picture Completion subtests; and Attention-Concentration, composed of Arithmetic, Digit Span, and Coding subtests. It was also proposed that such a factor-score approach would offer diagnostic information important for understanding the learning problems of specific individual children being assessed. Thus the usefulness of the WISC-R in psychoeducational evaluation would be enhanced.

Bannatyne (1968) suggested another recategorization of the WISC scaled scores to identify children with genetic dyslexia. His model has been one of the most popular areas of research in diagnosing learning disabilities with the WISC. For diagnostic purposes, Bannatyne's model suggests that the WISC subtest scaled scores should be categorized into Spatial, Conceptual, and Sequential areas. The Spatial score was derived from the scaled scores on the Object Assembly, Block Design, and Picture Completion Performance subtests. These subtests do not involve sequencing but require the ability to manipulate objects in multi-dimensional space either symbolically or directly, according to Smith et al. (1977a). The Conceptual score was obtained from scores on the Vocabulary, Comprehension and Similarities Verbal subtests, which together represent general verbal fluency. The Sequential category consists of the Digit Span, Coding, and Picture Arrangement subtests. These subtests usually require short-term memory storage and retrieval of sequences of auditory and verbal stimuli. These suggested recategorizations of WISC-R subtest scores proved to be higher in diagnostic value than the traditional Verbal-versus-Performance dichotomy, according to Smith et al. (1977a, 1977b).

Rugel (1974) reviewed 25 published and unpublished works on the WISC profiles of reading disabled children and categorized them according to Bannatyne's (1968) rank order. Rugel's (1974) work supported Bannatyne's (1968) recategorization scheme by citing factor analytic research. This led Bannatyne (1974) to add the fourth category of Acquired Knowledge, consisting of Information, Arithmetic, and Vocabulary subtests. Rugel's (1974) work also led Bannatyne (1974) to drop the Picture Arrangement subtest from the Sequential category and replace it with the Arithmetic subtest. More recently Smith et al. (1977a) found that school-verified learning disabled children exhibited Bannatyne's recategorization model scores on the WISC-R.

Vance and Singer (1979) added to Bannatyne's recategorization a Distractibility category consisting of the means of the Digit Span, Mazes, Arithmetic, and Coding scales. It was added after all 12 subtests were administered. The ANOVA data on the recategorized WISC-R scores yielded a significant F ratio ($p < .001$). The Newman-Kuels test showed significant pair-wise comparison between the Distractibility score and the Spatial (SP), Conceptual (CO), Sequential (SE), and Acquired Knowledge (AK) categories. Sixty-two percent of the subjects scored highest in SP, 27% in CO, 10% in SE, and 1% in AK. None of the subjects ranked highest in the Distractibility category. Altogether, 39% of the subjects obtained the same pattern of recategorized WISC-R subtest scores as that found by A. Bannatyne (1974) and Smith et al. (1977b). Using Bannatyne's regrouping and findings from the Vance and Singer study, it could be hypothesized that learning disabled children have good Spatial skills but are weak in those skills that involve general comprehension and attention.

Another model of WISC-R scores for reading disabled children was presented by Vance, Wallbrown, and Blaha (1978). Five meaningful profiles were obtained: (1) Distractibility; (2) Perceptual Organization; (3) Language Disability-Automatic; (4) Language Disability-Pervasive; (5) Behavioral Comprehension and Coding. Miller (1980) criticizes the procedure they used in developing these 5 categories since they eliminated 35 out of 128 students because they did not fit into their scheme and they never address what happened to these students. In a rebuttal Wallbrown, Blaha, and Vance (1980) explain that they were not attempting to come up with categories into which all learning disabled children could fit. Instead, they were quite aware that the five profiles were not all encompassing.

Combination Profiles

At the Child Guidance Center, University of Arkansas Medical Center, Sam Clements found three test patterns typical of the minimal brain-injured child (Clements, 1966).

WISC Pattern A

1. Scatter in either or both Verbal and Performance scales.
2. Low scores (relative to the others) most frequently in Arithmetic, Block Design, Object Assembly, Digit Span, Coding, and Mazes.
3. Final Verbal and Performance IQ scores often nearly equal. (Note internal inconsistency.)
   (a) Not uncommon to find Comprehension 5 to 10 points higher than Arithmetic.
   (b) Not uncommon to find Picture Completion 5 to 10 points higher than Block Design.

WISC Pattern B

1. Verbal IQ 15 to 40 points higher than Performance IQ. (In this instance the achievement on the other verbal tasks is sufficiently high to obscure or to compensate for a drop in Arithmetic. If the Arithmetic score is excluded, the difference is more pronounced, this test being another type of symbol process.)
2. Trouble with most of the performance scale items, particularly with the pure visual-motor tasks, which include Block Design, Object Assembly, Coding, and Mazes—less difficulty with Picture Arrangement and Picture Completion. (Often the Performance IQ falls within the mentally deficient range, while the Verbal IQ falls within or above the normal range.)

WISC Pattern C

1. Least frequent pattern.

2. Performance IQ 10 to 30 points higher than verbal IQ. (This child, generally considered to have dyslexia, has difficulty with verbal expression and must actively search for the words necessary to express a usually concrete solution to a "thought" problem. On the other hand, this child is quite proficient at the subtests that constitute the performance scale.)

Other authors have reported a larger number of possible patterns. McCarthy and Elkins (1975) enumerate five varieties of WISC profiles:

1. A profile showing few discrepancies between scaled scores or between Verbal and Performance scores with above-average scores.
2. A profile of low-Verbal, high-Performance scores.
3. A profile of high-Verbal, low-Performance scores.
4. A profile showing extreme discrepancies on both scales, but little difference between Verbal and Performance scores.
5. Low scores on all subtests.

Neuropsychological Findings

In clinical neuropsychology, a major emphasis has been placed on the use of comprehensive ability testing to detect and localize brain lesions. Many neuropsychologists use as their basic battery of tests those developed by Halstead (1947) and Reitan (1955, 1966). The sensitivity of these tests to acute and chronic brain lesions involving various etiologies and cerebral locations has been amply demonstrated (Reitan & Davison, 1974; Vega & Parsons, 1967). Studies have shown that an experienced clinician can use results from the Halstead-Reitan

Neuropsychological Test Battery to make valid inferences not only about the presence or absence of brain damage but also about the location and even the etiology of cerebral lesions in individual patients (Filskov & Goldstein, 1974; Reitan, 1964). Although Reitan (1966) has delineated some general strategies for interpretation, the specific application of these strategies to complex neurological test data is often based on extensive clinical experience and "intuitive" decisions. An objective and sensitive interpretive system would help to extend the clinical value of these procedures to places that do not have an expert neuropsychologist and would also facilitate future research with the Halstead-Reitan battery. The potential advantages of actuarial psychological test interpretation over more vaguely defined clinical methods have been discussed by various authors (Meehl, 1954; Sawyer, 1966; Spitzer & Endicott, 1974).

One approach to reducing the subjectivity in neuropsychological test interpretation has been developed by Russell, Neuringer, and Goldstein (1970). Their computerized "key approach" makes use of a variety of research results and inferential techniques advanced over the years by Reitan and others. The Russell et al. program first computes Phillip Resnick's Average Impairment Rating (AIR; discussed in Russell et al., 1970), using 11 measures from the Halstead-Reitan battery and one Wechsler Adult Intelligence Scale (WAIS) subtest pattern score. If the AIR is less than 1.55, the patient is classified as not brain damaged and the program execution terminates. If the AIR is equal to or greater than 1.55, the patient is classified as brain damaged and the computer program for the localization and process keys are executed. In the initial validation study (see Russell et al., 1970), this AIR cutoff correctly classified 94% of the brain-damaged subjects (n=80) and 71% of the controls (n=24). The localization key categorizes patients as having diffuse, right hemisphere, or left hemisphere brain damage. In the initial validation study, the agreements with neurological criteria for these relatively gross attempts at localization were 62%, 80%, and 81%, respectively. The Russell et al. process key classified patients as having acute, static, or congenital brain damage. Here the agreements with neurological assessments were 93%, 77%, and 88%, respectively.

Finkelstein (1977) recently developed a FORTRAN IV program for neuropsychological interpretation that is similar to, but neuropsychologically more sophisticated than, the Russell et al. (1970) key approach. This program, called BRAIN 1, uses several major methods of inference, including level of performance, differences in the efficiency of the two sides of the body on sensory-perceptual and motor tests, patterns of performance on cognitive as well as sensory and motor tests, pathognomonic signs of brain dysfunction, and knowledge of base rates. The program makes an initial determination of the probability of brain damage based on the Halstead Impairment Index, the Wechsler IQ and the presence or absence of either constructional dyspraxia or dysphasia. At later points in the program, this initial inference about the likelihood of brain damage can be upgraded if there are signs of lateralized or localized impairment.

Anthony, Heaton, and Lehman (1980) attempted cross-validation of these two computerized programs. They conclude that both programs in their current forms are of limited value. Although they reliably predict the presence or absence of brain damage, neither did significantly better than the Halstead Impairment Index in this regard. Furthermore, their results indicate that little confidence can be placed in most of the "finer" diagnostic distinctions made by these programs regarding the location, chronicity, and etiology of cerebral lesions.

These three systems, Key approach, BRAIN, and Halstead Impairment Index, are primarily available for the adult version of the neuropsychological test. It has not been until most recently that Selz and Reitan (1979) devised an actuarial system for the Halstead Neuropsychological Test Battery for Children. Their set of rules categorizes 9 to 14 year old children as normal, learning disabled, or brain damaged. The previous systems have been mainly concerned with distinguishing between the two more distinct categories of normal versus brain damaged. The rules utilize Reitan's four methods of inference: (1) level of performance; (2) patterns; (3) right-left differences; (4) pathognomic signs.

Analysis of the protocols of pilot subjects (Selz, 1977) resulted in the 37 rules presented in Table 1. The derivation of Rules No. 18 and 19 is presented in Table 2. Since the raw scores on different tests cannot be added together directly, a 4-point scale conversion was developed. According to this system of scaled scores, a score of 0 represents performance in the normal to superior range; 1 indicates performance slightly below normal standards; 2 represents performance probably below normal limits, yet not considered to be definitive for brain damage; and 3 indicates definite impairment. The Aphasia battery is scored in a somewhat different manner: Normal performance is scored 0, and abnormal performance is scored 1, 2, or 3 based on the judged

Table 1

Selz and Reitan Scoring System

Test	0	1	2	3
Level of Performance				
1. Category-errors	34 or less	35-55	56-74	75+
2. Tactual Performance Test (TPT) - total time	less than 6'	6-9.9'	10.13.9'	14'+
3. TPT-memory	6, 5	4	3	2, 1, 0
4. TPT-localization	3+	2	1	0
5. Trails A-time	15" or less	16-25"	26-35"	36"+
6. Trails B-time	39" or less	40-55"	56-70"	71"+
7. Speech-errors	10 or less	11-15	16-20	21+
8. Rhythm-correct	25+	21-24	16-20	15 or less
9. VIQ	90+	80-89	70-79	69 or less
10. PIQ	90+	80-89	70-79	69 or less
11. FSIQ	90+	80-89	70-79	69 or less
12. Tapping, preferred hand - # taps	34+	30-33	26-29	25 or less
13. Tapping, non-preferred hand - # taps	30+	27-29	23-26	22 or less

Pattern: Extreme scatter on the subtest scores on the Wechsler scale is abnormal. The following conversion measures the degree of scatter: (largest subscale score - smallest subscale score) ÷ mean of scores.

14. Pattern IQ	.99 or less	1.00-1.40	1.41-1.75	1.76+

Right-Left Differences: The following tests compare performance of the right and left hands. Ratios for #15-17 are derived from this formula: 1 - (nonpreferred hand ÷ preferred hand). The scores in #18 and 19 are derived from the conversion formula presented in Table 2.

Table 1 (continued)

Test	0	1	2	3
15. Tapping	.04-.16	.03-(-.15)	-.16-(0.25)	-.26 or less
		.17-.30	.31-.40	.41+
16. Grip	0.0-.20	-.01-(-.06)	-.07-(-.12)	-.13 or less
		.21-.26	.27-.32	.33+
17. TPT	.11-.49	.10-(-.05)	-.06-(-0.20)	-.21 or less
		.50-.65	.66-.80	.81+
18. Name writing - preferred hand (converted score- see Table 2)	10, 8	6, 4	2	0
19. Name writing- difference (converted score- see Table 2)	6-10	4	2	1
20. Tactile finger recognition. Right hand errors Left hand errors	0, 1	2	3	4+
21. Finger-tip number writing. Right hand errors Left hand errors	0-2	3-4	5-6	7+

Pathognomonic Signs: For these tests, normal performance consists of perfect performance. Allowance was made for the fact that even normal children tend to make more errors than adults.

22. Imperception- errors	0	1	2	3+
23. Tactile Finger recognition-errors	0-3	4-5	6-8	9+
24. Finger-tip number writing-errors	0-7	8-10	11-14	15+
25. Tactile form recognition-errors	0	1	2	3+

Table 1 (continued)

Test	0	1	2	3
Aphasia Battery	Score for Deviant Performance			
26. Constructional Dyspraxia	2			
27. Dysnomia	3			
28. Spelling Dyspraxia	1			
29. Dysgraphia	2			
30. Dyslexia	2			
31. Central Dysarthria	2			
32. Dyscalculia	2			
33. Right-Left Confusion	1			
34. Auditory Verbal Dysgnosia	3			
35. Visual Number Dysgnosia	3			
36. Visual Letter Dysgnosia	3			
37. Body Dysgnosia	3			

Table 2

Name-Writing Test Conversions

Preferred Hand		Nonpreferred Hand		Difference (Nonpreferred-Preferred Hand)	
Time	Converted Score		Converted Score		Converted Score
				Preferred hand slower	2
0-9"	10	0-29"	7	0-4"	4
10-14"	8	30-69"	6	5-9"	10
15-19"	6	60-69"	4	10-14"	8
20-24"	4	70-84"	2	15-19"	6
25-50"	2	85" or more	1	20-24"	4
50" or more	0			25-44"	2
				45" or more	1

significance for impaired brain functions or deficit on a particular task for the age group employed. For example, any error on a relatively simple task such as letter recognition is scored 3, whereas errors on more difficult tasks for this age group such as spelling are scored 1. Table 1 presents the 37 rules, and the range of performance included by the scaled scores.

The 37 rules were applied to 75 subjects who were previously documented as falling into a control, learning disabled, or brain-damaged category. For the control subjects, the range for sum of scaled scores included values from 1 to 25 with a mean of 10.60 and a standard deviation of 6.62. For the learning disabled subjects, the range included values from 8 to 43 with a mean of 24.44 and a standard deviation of 9.61. For the brain-damaged subjects, the range included values from 11 to 74 with a mean of 40.60 and a standard deviation of 18.51. Two-tailed test comparisons indicated that the three distributions were significantly different from each other well beyond the .001 level. On the basis of the sum of scaled scores for all 75 subjects, cutoffs were deliberately selected to result in the fewest misclassifications. Subjects scoring 19 or below were classified as normal; children who scored 20-35 were classified as learning disabled; and individuals scoring 36 or above were classified as brain damaged. The resulting classifications are presented in Table 3. According to the classification matrix in this table, 73.3% overall correct classification among the three groups was achieved.

Although the rule system lacks the clinical insight of the skilled clinician, it appears it is capable of making an important discrimination—

between normal, learning disabled, and brain-damaged children—with a fair degree of accuracy (Selz & Reitan, 1979).

Table 3

Classification Matrix for Rules

Group	Classification According to Rules			
	Control	LD	BD	Total
Control	24	1	0	25
LD	8	14	3	25
BD	4	4	17	25
Total	36	19	20	-

Note: LD = learning disabled; BD = brain damaged.

The learning disabled group consisted of children who appeared normal on the physical neurological examination (not including computed tomography); almost two-thirds of these children were correctly classified as learning disabled on the basis of neurological classification. The result addresses the question of the possible neurological etiology of learning disability. On the basis of these results, it seems that many cases of learning disability represent brain functions that appear normal on routine neurological evaluation but that are somewhat deviant from normal brain functions on the basis of neuropsychological evaluation.

Because neuropsychological diagnosis appears to be more sensitive to subtle, higher level cognitive dysfunction than is the neurological exam (Kløve, 1974), it is implied that learning disability represents fairly normal lower level functions (as represented in the neurological examination), with impairment primarily evident in the higher level cognitive processes (as indicated in the neuropsychological examination).

Furthermore, since all of the learning disabled subjects were in the normal range according to the physical neurological exam (two-thirds were classified as having learning disabilities by the neuropsychological exam), it follows that neuropsychological screening for learning disability may be far more effective than neurological screening. The rules system provides a convenient method for interpreting test results and, subject to cross-validation, could be used as a neuropsychological screening procedure.

EEG Findings

The existence of the EEG patterns were discovered in 1929 by Berger. At this point there were great hopes and speculations that we would then be able to explore all the intricacies of the brain. We have come a long way but not as far as many had hoped. The EEG signifies the condition of the cerebral cortex at the time of the recording. The brain sends out energy waves, electrodes placed on the head pick up the waves being transmitted and the waves are passed into a machine where they are amplified and recorded on graph paper. Thus, the EEG represents an averaged signal from many cells. The four major patterns of the EEG are categorized by their frequency and they often have a general mental state associated with them. These are listed below:

Delta	1-3 Hz	Deeper sleep
Theta	4-7 Hz	Early stages of sleep
Alpha	8-13 Hz	Relaxed wakefulness
Beta	14 Hz+	Alertness-Thinking

An additional rhythm that appears in the literature is SMR (Sensorimotor Rhythm) which is 12-14 Hz and which is recorded over the Sensorimotor cortex. In their research reports some researchers divide the categories into smaller parts such as Alpha 1 and Alpha 2 so that one has to be careful in comparing results.

A number of general patterns can be investigated although the most widely used are background EEG or EEG in response to a particular stimulus. In this second category the subject's response will either be lessening or blocking of alpha waves. This is referred to as an alpha attenuation response (AAR).

There are three types of EEG recordings utilized in the literature. The first, the traditional EEG, is what is typically ordered by a physician and is read and interpreted by an electroencephalographer. Although methods of this type have been most helpful in determining major problems such as tumors or seizures, they have not been as helpful in investigating the neurological functioning of the MBD child. A second more precise method is that of Fast Fourier power spectral analysis of the EEG. Here the whole 20-40 minute reading is compressed into a single page making interpretation much easier. Clinical impressions are still required and great care must be taken to avoid artifacts caused by eye movements (Bickford, Brim, Berger & Aung, 1973). Third, John (1977) and his colleagues have developed the NB system which cuts the recording time down to two minutes yet offers a multitude of measures. Preliminary data for this procedure have offered much more success in differentiating learning disabled children from normals. Most of the research reviewed here has utilized the traditional EEG recordings but whenever the spectral analysis or John's NB has been used this will be indicated.

Before one can effectively interpret the literature one must have a general idea of normality in regards to the EEG. Abnormality can be separated into definitely abnormal signs and questionably abnormal signs. These areas follow:

Definitely Abnormal

1. paroxysmal spike-wave discharges
2. paroxysmal polyspike complexes
3. repeating focal spiking or slowing
4. amplitude asymmetries greater than 50%
5. marked and diffuse dysrhythmias

Questionably Abnormal

1. 14 and 6 per second positive spikes
2. occipital or posterior temporal slowing
3. nonfocal sporadic sharp waves
4. excessive slowing or amplitude
5. mild diffuse dysrhythmias

Recent studies have shown that normal children who were selected because of absence of clinical abnormalities will show up with 20-30% having abnormal EEG indicators, especially the questionable ones listed above. The 14 and 6 per second spike was once regarded as indicating thalamic or hypothalamic seizures until Lombroso (1966) found a 58% incidence in the general population. No other investigator has found this large percentage. Hughes in his reports has generally noted an incidence of 15% in normal controls. Secondly, the occipital or posterior temporal slowing has been found in normals by many researchers including Westmoreland and Stockard (1977). Third, the sporadic sharp waves have been seen in 6% normals (Hughes, 1971). Fourth, diffuse slowing has been found in the general population where you tend to get these slow waves in approximately 13% of the normals. When Hughes looked at a general population of children he found that slow waves accounted for 50% of the EEG abnormalities but only 1% of these were considered marked slowing. Fifth, as a general rule, amplitudes are larger on the subdominant hemisphere. This wide range of patterns must be kept in mind when interpreting research results. Recently researchers realized that we had a great need for some comprehensive normative data. Matousek and Petersen in Sweden undertook this task and published the final results in 1973. John (1977) in his pilot study discovered that we really need United States norms as the data for American 9 year olds were slightly different.

The Matousek and Petersen (1973) article gives a thorough description of maturational changes in the normal population. They looked at 400 children and 160 adolescents who were not related by blood in any way and who were considered normal by very stringent criteria. Age differences are listed below:

1. Age dependent changes are more noticeable in posterior readings for children but anterior for adolescents.
2. The asymmetry in temporal derivations increases with age.
3. Between subject variability increases slightly with age.
4. Within subject variability tends to decrease in children and increase in adolescents.

5. Delta decreases almost linearly with age.
6. Theta and Alpha 1 (7.5-9.5 Hz) increase up until age 4-8 and then they both decrease.
7. Alpha 2 (9.5-12.5 Hz) increases in childhood but remains stable during adolescence.
8. The amplitudes in Beta decrease slightly.
9. Beta activity increases with age.

MBD Children

The research on the EEG's of other than normal children is very difficult to integrate and logically delineate for many reasons. The main problem is the definition of the subject population. In one study a learning disability population will be chosen because they are believed to have neurologically based learning problems and in another study the learning disabled group will be chosen solely because they are underachievers. Many researchers such as Conners (1973) have shown that these children are a most heterogeneous group; however, the literature does suggest that the EEG is one of several useful procedures for delineating MBD children. In an attempt to organize the studies three major categories have been chosen; however, one must realize that they are definitely not mutually exclusive.

Learning disabled children. Although Hughes (1976) realizes that it is not advisable to average percentages from varying studies, he has done this and come up with 45% incidence of abnormal EEGs. This average includes a wide range from 25% to 95%. In most cases the researchers are including the minor or questionable abnormalities that were listed previously. Schain (1970) reports only 5-10% incidence of the definite abnormalities. In some studies the percentage has depended upon age. Klonoff and Low (1974) report that EEG abnormalities are more common in younger Minimal Cerebral Dysfunction (MCD) children (2-9 years) than older MCD children (9-15 years). John (1977) with his more precise EEG recording found that 49 out of his 50 LD subjects had one or more abnormal EEG feature. Moreover, traditional EEG evaluations had been either negative or borderline.

Hughes has reported on some very provocative findings in a project directed by Myklebust and Boshes (1969). They looked at 8-11 year old LD children in comparison to normal controls. LD children were chosen based on underachievement in relation to potential and a particular cut off was determined. They also decided to look at those they called borderline in regards to academic achievement. When they looked at the EEGs they surprisingly found that the borderline children had EEGs that were more abnormal than both the learning disability group and the controls. In fact, the borderline group was statistically significantly different from controls but the differences between the controls and the learning disabled group did not reach statistical significance.

In reviewing the literature, there are eight types of EEG abnormalities that have been reported in learning disabled children. The first one and most controversial is the 14 and 6 per second positive spike. Ten years ago there were numerous papers written on its clinical significance but due to Lombroso's study mentioned earlier they are now considered normal by many electroencephalographers. Hughes in his writings reports that although these are common among adolescents, this should not negate their clinical difference in other groups. He has found a higher incidence in learning disability children than controls and he believes this should not be ignored. Roberts (1966) suggests that these patterns are related to auditory perception problems.

Positive spikes are the second abnormality. They have been reported in many different studies dealing with learning or behavior disorders. Stevens, Sachdev, and Milstein (1968) in their behavior disorders (subjects were also reported to be clumsy and poor in arithmetic) found a 36% incidence of positive spikes and Hughes (1971) found 20%. This seems fairly significant until one investigates their control groups. In the Stevens' study one control group also had 36% but another control group had 15% incidence compared to 20% which shows a general trend but was not statistically significant. Moreover, Hughes' borderline group mentioned earlier had a larger percentage of positive spikes than the learning disabled group. Roberts (1966) reports that children with visual perception problems often have bilateral occipital or parietal spiking. Other researchers have associated positive spikes with impulsivity. John (1977) using his more precise neurometric system reports significantly more positive spikes in LD children.

The third abnormality is the sharp wave or epileptiform discharge. In an earlier study in the 1930s approximately 40% incidence was reported in children with behavior disorders, but the definition at that time was much broader than today. Whereas Paine (1962) and Gubray, Elles, Walton and Count (1965) both report that one-third of their subjects with abnormalities had this pattern, Hughes (1971) reports less than 6%. Stevens et al. (1968) found that children with these spikes had defects in attention and ideation. Others have reported both visual disorders and attention problems. Predescu, Roman, Costiner, Cristian, and Oancea (1968) noted that this pattern disappeared with age in MBD children.

A large portion of the studies report the fourth abnormality or posterior slow wave activity as the most prominent abnormality of learning disabled children. Occipital slowing is associated with hyperactivity and visual motor performance tests (Pavy & Metcalfe, 1965). Hughes (1971) reports that temporal slowing rather than occipital best delineated the borderline group from the controls. The slowing in the temporal area was only on the left side for the learning disabled group but it was bilateral for one-half of the borderline group. Hughes proposes that symmetrical slowing may be better for academic achievement since the borderline children were higher academically. John's (1977) spectral analysis of a pilot group of learning disability children supported the findings in earlier literature of excessive posterior slowing (parieto-occipital area) with a 70% incidence. He suggests that these children might be weak in processing visual information since he has found that the parietal regions are significant in mediation of abstract visual input. This research also showed that 68% had slow waves in the frontal regions which indicates that they may show problems in the ability to control impulsivity and to plan ahead. A third interesting finding is that no child had abnormal patterns in the temporal region alone. This is noteworthy since these children often have language and reading problems. Last, no single slowing pattern was noted, so again this points out the heterogeneity of this group.

Diffuse slowing or immaturity is the fifth pattern and it seems to suggest some type of nonspecific problem that is related to maturation.

Gubray et al. (1965) in their study on apraxia and agnosia found that this was the major abnormality. Capute, Niedermeyer, and Richardson (1968) found that 50% of their MBD/LD children had diffuse slowing. Stevens et al. (1968) report that this abnormality is associated with antisocial behavior, low frustration tolerance, and clumsiness. Most recently Shabsin (1980) has noted that learning disabled students do not speed up their brain waves when they are presented with an academic task. Instead their EEG recordings during an activity are more like the slower waves that are seen during the baseline recordings of the normal children.

The sixth abnormal finding is asymmetry. John (1977) obtained EEG asymmetries in his pilot study on learning disabled children. Other researchers have found a high level of asymmetry in the resting EEGs of underachievers. Shabsin (1980) reports the left hemisphere of the learning disabled child does not appropriately process verbal material as is seen in the normal child. Instead, it appears that they utilize the right hemisphere for verbal processing.

Alpha blocking, the last identifying characteristic, has been associated with attention in the literature. Peter Fuller (1976) in his doctoral dissertation looked at the alpha blocking in learning disabled and normals under three conditions: (1) immediate memory, (2) digital and word problems in arithmetic, (3) teaching period. He found that the learning disabled had significantly less blocking for immediate memory and arithmetic which he concluded indicated an attentional deficit in the learning disabled population. Shabsin (1980) also found a deficit in alpha production during a baseline time period.

Dyslexic children. Dyslexic children are a subset of learning disabled children and have probably been included in the studies previously cited. However, there are a number of studies reporting EEG data for reading disabled children as a group. The findings are similar in many respects to a general learning disability population. Quoting again from Hughes' (1976) article where he averaged the percentage of EEG abnormalities in a number of studies, he gives a 44% abnormality for dyslexics. He reports a range of 34% (Ingram, Mason & Blackburn, 1970) to 63% (Muehl, Knott & Benton, 1965). Another higher percentage in the literature, which was not included by Hughes, was Goldberg (1960) who found 80% abnormalities.

The types of abnormalities reported are like those in the general learning disabled population. Hughes and Park (1968) found a 17% incidence of the 14 and 6 per second positive spikes which is the same percent Hughes (1971) found in learning disability children. There are conflicting results regarding the presence of positive spikes in general. Some report from 20-50% incidence of positive spikes in dyslexic but other studies have claimed no difference between the dyslexics and the normals (Torres & Ayers, 1967). Excessive occipital slowing predominates in some studies such as 50% in Knott, Muehl & Benton (1965). Others such as Hughes and Park found only 10% incidence but it was noted that these 10% were the poorest readers and they displayed poor visual perception. Generalized slowing is reported by Muehl et al. (1965) and others. There again is wide disagreement regarding the sharp wave (epileptiform discharge). Hughes and Park indicate that less than 4% of the dyslexics had this pattern but Torres and Ayers claim that focal spikes on the temporal areas were the most common abnormalities. Last, asymmetrics were found by both Muehl et al. (1965) and Sklar, Hanley, and Simmons (1973).

This last study (Sklar et al., 1973) involved spectral analysis during a resting situation as well as a reading task. The most outstanding difference in dyslexics and normals was in the resting (eyes closed) situation. Here the dyslexics had in the parieto-occipital region more energy in the Theta (3-7 Hz) and Beta (16-32 Hz) whereas the normals had more energy in the Alpha (9-14 Hz). When it came to reading the normals had more energy in the Beta range. This is what one would expect since Beta is the alert, thinking state. Another interesting finding was that dyslexics had higher coherence between regions in the same hemisphere and the normals had higher coherence between the same regions across hemispheres.

Hyperactive children. As with the dyslexics, hyperactive (HK) children were undoubtedly included in the learning disabled studies since Silver (1975) reports that 94% of HK have learning or language disorders and 38% of learning disabled are also hyperactive. However, since some research has looked at the EEGs of HK specifically, these results will also be reported separately. There are three major abnormalities reported in the literature:

1. Excessive occipital slowing. This pattern is found in a higher percentage of behavior problems than learning disabled in general and hyperactive more often than not are behavior problems. A number of

studies including Knobel, Wolman, and Mason (1959) have shown occipital slowing near 50% of HK and thus it is reported as the major abnormality.

2. Diffuse or generalized slowing. Numerous studies in the 1960s (Anderson, 1963; Klinkerfuss, Lange, Weinberg & O'Leary, 1965) showed marked and generalized slowing as the most prevalent abnormality. In the 1970s many studies by Satterfield and his associates (Satterfield, 1973; Satterfield, Cantwell, Lesser & Rodesin, 1972; Satterfield, Cantwell, Saul & Alvin, 1974) confirmed this finding. On the one hand this might suggest that HK have an immature EEG pattern since the EEG tends to increase in frequency with age; but, on the other hand, some researchers have reported premature development of the AAR (Alpha Attenuation Response) in HK. Thus, no conclusions can be drawn either way.

3. Decreased SMR (sensorimotor rhythm). Most recently Shouse and Lubar (1978) have reported their study on hyperactive children. They found that hyperactives with low CNS arousal had a decreased amount of SMR (12-14 Hz) as compared to normals and they suggest that SMR has potential value for diagnosis of hyperactivity.

Grunewald-Zuberbier, Grunewald, and Rasche (1975) have compared the spontaneous EEGs of HK with children who were maladjusted but not hyperactive. They found that HK had higher alpha and beta amplitudes, more alpha waves, smaller amounts of beta waves, and longer AARs.

John (1977) says that there is not a definite relationship between EEG characteristics and drug response. It appears that the AERs (Average Evoked Responses) are more helpful in this regard. On one side Satterfield (1973) and Satterfield et al. (1972) have reported that the HK with the most slow waves respond best to stimulant drugs. He claims that the drugs make the EEG more like that of the normals. On the other side at least two studies (Burks, 1968; Gross & Wilson, 1974) have shown that medication is more effective with children with normal EEGs.

EEG Correlation with Psychological Data

In a thorough discussion of the diagnostic value of the EEG in identifying MBD/LD children the relation between the EEG and other diagnostic tools, especially psychological testing, should be noted. A number of studies in the past have dealt with this issue. In 1965 Muehl et al. found no correlation between positive spikes and any psychological test. Hughes and Park (1968) as well as Pavy and Metcalfe (1965) both found that occipital slowing was associated with poor performance in visual perception tests. Hughes and Park also found that those with positive spikes were the brightest of their four EEG groups but they were also underachieving the most in relation to potential. Stevens et al. (1968) found no correlation between global test scores and the EEG but they did find a relationship between individual psychological test items and the EEG.

Into the 1970s Hughes (1971) reported that the child with lowered performance skills versus verbal skills was more likely to have an abnormal EEG so he suggested that right hemisphere problems may show up more often than left hemisphere problems on the EEG. In 1974 Klonoff and Low used a neuropsychological battery (Reitan-Indiana Neuropsychological Test for Children, Ages 5-8 and the Halstead-Reitan

Neuropsychological Test for Children, Ages 9-14) that has proven in the literature to be more precise in determining neurological dysfunction than the typical psychological battery. They found a significant correlation between the EEG and the Reitan. They say that Stevens and her colleagues did not find this correlation due to the nature of their psychological tests.

In a study of 57 learning disabled boys (7-1/2-9-1/2 years old) John (1977) had attempted to correlate the psychological and educational testing with his neurometric measures (NB). He could not find any significant correlation between the two, so he has concluded that they represent different types of dysfunction. Both measures correlate significantly with a prediagnosis of LD but the NB was higher (.6) than the psychological testing (.3). He believes that the EEG provides a more direct measurement of brain dysfunction based on these results. Speculation is that the EEG is not biased by socioeconomic status, culture or intelligence. Another positive aspect is that the NB can be used down to infants whereas the psychological testing is not reliable under 3 years of age. He concludes that his more refined EEG measures are more efficient but he believes that the most accurate picture of dysfunction would be to use both.

Average Evoked Response (AER)

With the coming of more advanced computer technology, a special EEG technique called the AER has been devised. The AER is a method where certain brain responses are abstracted from the mass of electro-chemical activity in the brain. The responses to stimulus are averaged and recorded so that definite comparisons can be made both within subjects and between subjects. There seems to be agreement in the literature that these responses provide a sensitive and powerful measure of sensory information processing and can also show changes during learning. These responses show promise both as a research as well as diagnostic tool. There are two main advantages over the EEG (John, 1977). First of all the AERs are under stimulus control and second a more quantifiable analysis such as amplitude and latency of the wave components can be compared.

By presenting a stimulus ranging in intensity from low to high, researchers have found noticeable differences between people's responses. In general, the AER data on LD children indicate poorly formed components; longer latencies (Musso, 1976); significant differences of asymmetry (John, 1977); and problems with habituation (Barnet & Lodge, 1967). More specifically, children with visual perceptual problems are found to have higher or more variable amplitudes and longer latencies when processing visual information (Musso, 1976; Shields, 1973). There has been contradictory results regarding the diagnostic value of AERs in children with reading difficulties. On the negative side Weber and Omen (1977) found no differences between dyslexics and normal children. In contrast, the AER differences in disabled and normal readers have generally supported an attentional deficit hypothesis. While those children with visual perception problems show increased amplitude in attempting to process information that is difficult for them, the disabled readers do not. Instead, they show reduced amplitudes (Conners, 1970; Preston et al., 1974) or increased amplitudes at inappropriate times (Sabotka & May, 1977).

Treatment Procedures

The types of remediation procedures that have been attempted fall into three main categories: medical, psychological, and educational.

Medical Treatments

The medical therapy has been primarily administration of various drugs to help reduce poor impulse control and increase concentration and attention span. Other more controversial therapies include patterning, optometric training, sensory integration therapy and orthomolecular medicine.

Drug therapy. Ross and Ross (1976) indicate that drug therapy is the most prevalent approach to reducing distractibility and increasing concentration. It is most often used as the sole treatment by physicians because, if effective, it offers quick results with minimal time expenditure. Although it should require time to manage and stabilize the medication, this time is sometimes not taken. Schaefer and Millman (1977) say that many are recognizing that when drugs are used other psychological and educational approaches are also needed in order to obtain the best results.

The use of drugs in this respect is not a recent approach. The Greeks prescribed opium for colicky babies and in the late 1800s barbituates were used. Psychostimulants are a product of this century so they are relatively new. In the late 1930s and early 1940s it was reported that amphetamines helped behavior and learning but little interest was shown them until the late 1950s when they gained wide acceptance and usage. From 1965 to 1970 criticism began to reign.

Although the mass media reported that as many as 10% of all children were on these drugs, surveys give a more realistic figure of 2%.

Although many have tried, there is no way that general statements can be offered about the effectiveness of drugs. The results depend upon who, how old, why overactive, which drug, how much drug, what environment, and many other variables. Conrad and Insel (1967) claim that research reveals a 70% positive reaction but clinicians seem to report more near 30%. Sometimes children have immediate positive results (as well as negative) and then sometimes these positive results decrease over time, i.e., tachyphylaxis. Some researchers such as Millichap (1972) believe there are not only changes in activity level and attention span but also improvements in cognitive tasks. Some say the drug results are best with the most active or the child who shows the greatest number of abnormalities. In essence, there is no consensus on effectiveness.

There are many types of drugs utilized to reduce children's activity levels so that they can attend to the tasks at hand. The psychostimulants have been the most popular although other things have been tried such as major tranquilizers, minor tranquilizers, antidepressants, anticonvulsants, and caffeine.

Patterning. The patterning theory was originally developed by Doman and Delacato and they are still carrying on treatment at their Institute in Philadelphia. They say that a child's failure to pass through certain developmental stages are indications of neurological problems. An example would be the child who never crawled but went right from sitting to walking. Part of the treatment for a dyslexic

9 year old who never crawled would be to go through crawling exercises so that the brain could be patterned. Other techniques include sensory stimulation, rebreathing air in a face mask to stimulate cerebral blood flow, and cutting out fluids, sugar and salt intake supposedly to decrease spinal fluid production and cortical irritability. This group assumes that language is localized in the dominant hemisphere and tonal skills in the subdominant hemisphere, although this has been questioned in recent studies by Sperry and Ornstein. During treatment periods they insist that all tonal abilities (e.g., music on the radio) be avoided. This is a very comprehensive and involved program that requires great effort on the family's part. Some have said that when the Institute experiences failure they say that the parents did not stringently carry through with the program. A number of professional agencies have put forth negative statements regarding this therapy and there is little evidence of sound research.

Optometric training. A portion of optometrists have broadened their role in dealing with children both from a diagnostic and remediation standpoint. They often give the parents eye exercises to do at home with the child. Another component is visual perception activities that are carried out in the optometrist's office. Some of the exercises are similar to those done by resource teachers or learning disability therapists. The major problem here is that only 17% of dyslexic children have visual perception problems (Mattis, French & Rapin, 1975) so optometric training is not appropriate for a large number of the children with reading difficulties. In 1972 the American Academy of

Pediatrics and the American Academy of Opthamologists issued a joint statement summarized in the three statements below:

> 1. Dyslexia requires remediation from a number of disciplines, especially education.
> 2. There are no known peripheral eye problems that cause dyslexia.
> 3. There is no evidence at this time that visual training or neurological reorganization exercises alone can improve reading skills.

Sensory integration therapy. This therapy was formulated by Jean Ayres to develop sensory integration in children with learning deficits. The underlying theory says that the person's ability to react to auditory and visual stimuli is dependent upon the brain stem's ability to organize the auditory and visual processes. Therefore, if the brain stem (subcortical) is malfunctioning then the child may have learning disabilities (Ayres, 1965, 1969). The problems include poor posture, poor muscle control, poor visual orientation, and problems processing auditory stimuli. In order to remediate she says that controlled sensory input can be fed to the vestibular and somatosensory systems. These exercises help intersensory integration and according to Ayres also improve communication between the two hemispheres. This therapy is seen as helping learning disabled children in both the visual and auditory area (DePauw, 1978). Much to Ayres chagrin, groups of occupational therapists have opened centers purporting to follow her guidelines but not truly understanding the process.

One study completed by Ayres in 1974 claimed statistically significant increases among young disabled learners after training; however, research by others has been minimal. The overall stated objective of the author is "to enhance the brain's ability to learn how to do." Little evidence to-date has been offered to suggest that any intervention program will change the brain processes or mechanisms or allow for transfer to the mastery in language skills. The goals appear ambitious but it is possible that some of the program may help children gain more control over their motor and perceptual action and therefore build some self-esteem (Sapir & Wilson, 1978).

Orthomolecular medicine. Pauling (1968) defines orthomolecular medicine as a method of treating mental problems by providing the best molecular environment for the brain, especially the appropriate amounts of substances that are normally in the body. Under this category of medicine there are five theories regarding the etiology of such learning problems as short attention span, impulsivity, distractibility, and poor concentration.

1. Megavitamins. The use of megavitamins first began in the treatment of schizophrenics. Where initial research reported positive effects, follow-up research did not support the theory. The first paper to suggest this treatment with learning disabled children was written in 1971 by Dr. Allen Cott. He used the same theory as that for schizophrenics and found positive results with 500 cases. However, these children were not primarily MBD children but rather autistic and schizophrenic. Although many say that the usefulness of megavitamins has never been proven for these children, the approach is still popular.

2. Trace element. In this same 1971 paper by Cott, the author proposed that hyperactivity and learning disabilities could be caused by deficiencies of various elements such as copper, zinc, magnesium,

calcium, sodium and iron. He gave no research to support these hypotheses and no follow-up data have been positive. Nevertheless, in many parts of the United States children are being treated with this type of therapy.

3. Hypoglycemia. Another approach says that these problems are secondary to hypoglycemia. This was also suggested in the Cott paper, but there has been no data to support this either.

4. Allergies. There have been many reports relating hyperactivity and other CNS reactions to allergic conditions particularly food allergies. The physiological cause has never been determined but there are some hypotheses. Moyer (1975) says that the allergies affect the central nervous system by causing swelling of the brain and this effects the area that controls aggression. Although some people such as Taub (1975) have reported great improvement with diet restriction, there have not been enough controlled studies to support this contention.

5. Food additives. Another type of diet control regards the elimination of foods with artificial coloring and preservatives and the name primarily associated with this is Feingold. The research suggests that this may be appropriate for a small percentage of overactive children but not all by any means. Keith Conners has been doing studies for three years and has found a small percentage of children that respond. Silver (1975) reports a study that compared placebo, nutrition, and drugs and found a small portion that reacted well to the diet. It seems that this hypothesis cannot be totally disregarded but it is not the blanket solution.

Psychological Treatments

The main psychologically oriented treatment procedures include the following approaches: behavior therapy, psychotherapy, environmental techniques, biofeedback, and neurotherapy.

Behavior therapy. Behavior modification procedures are being used increasingly in training programs with children diagnosed as learning disabled (Lahey, 1976). A frequent finding from this work is the fact that on many occasions the academic problems of these children can be remediated through the systematic manipulation of basic instructional methods. Lahey, Busemeyer, O'Hara and Beggs (1977), for example, treated perceptual-motor disorders of learning disabled children by providing feedback for incorrect responses (informing a child why a response was incorrect) and rewarding correct responses with tokens which could be exchanged for pennies. Luiselli and Downing (1980) report that providing feedback for completed work and reinforcing gradual increases in responding were effective in improving the rate at which a student completed mathematics problems. Similar results have been reported by Smith and Lovitt (1973) and Drass and Jones (1971). These findings are encouraging since they demonstrate that academic problems can be remediated by procedures which are easily communicated to teachers, simple to implement, and cost-efficient. In the schools a number of rewards are used including recess, free time activities, special privileges, teacher attention, and primary reinforcement. Sometimes these rewards are administered individually and sometimes on a group contingent basis. Both are effective but studies find varying results as to the relative effectiveness.

There is a great deal of research comparing the results of drug and behavior therapy. Some people such as Stableford, Butz, Hasazi, Leitenberg, and Peyser (1976) believe that behavior management should be tried before resorting to drugs in an attempt to increase attention span. In contrast, Silver (1978) says that an overactive child may be able to put enough energy into a modification system but he would rather let the medication do this and thus allow the child to put his energy into learning. Some of those who have reported that behavior therapy has equal or better effects in increasing attention span are Shafto and Sulzbacher (1977), Pelham (1977), Stableford et al. (1976), and Christensen (1975). However, unless the behavior therapy includes modification of academic skills there has been no clear cut evidence that attempting to increase concentration alone yields higher educational performance.

Within the broad area of study aimed at enhancing the effectiveness and efficiency of learning, growing attention has focused on the implications and applications of self-control techniques (Mahoney & Thoresen, 1974; Thoresen & Mahoney, 1974). The general focus of these studies has been to create conditions which free the teacher's time and allow for more individual problem-oriented tutoring by transferring some of the management functions to the pupils themselves.

Various approaches have utilized information or performance feedback (Fink & Carnine, 1975; Van Houten, Morrison, Jarvis & McDonald, 1974; Van Houten, Hill & Parsons, 1975), self-monitoring and recording (Johnson & White, 1971; McFall, 1970; Seymour & Stokes, 1976; Thomas, 1976), self-graphing (Fink & Carnine, 1975; Willis, 1974), public display of performance (Van Houten et al., 1974, 1975; Willis, 1974), self-grading and evaluation (Hundert, 1976; Van Houten et al., 1974, 1975) and self-selected or imposed rewards (Ballard & Glynn, 1975; Bolstad & Johnson, 1972). Many of these approaches involved treatment packages which, while effective did not permit the identification, with certainty, of the critical and/or most potent components of change. As Willis (1974) points out, little is known about the relative importance of these components. Often, nonself-control variables such as instructions, teacher feedback, praise and other reinforcers may be involved.

Previous studies have shown that various forms of information feedback in conjunction with other procedures have been effective. Van Houten et al. (1975) found that timing plus feedback improved story writing, reading comprehension, and word meaning exercises in elementary school pupils, independent of the effects of public posting and praise. Fink and Carnine (1975) found that it was possible to reduce arithmetic errors in first graders by the use of information feedback plus graphing. Similarly, Willis (1974) increased the number of correctly read sentences of elementary age remedial reading pupils by a program focusing on feedback and self-charting. Self-monitoring has modified both study behavior and academic performance in elementary students.

Paquin (1978) reports that the advantage of a self-control approach are fourfold. First, it is a simple technique which allows the teacher more freedom than more time consuming, expensive token economy systems (Van Houten et al., 1974). Second, it deals directly with the primary goal of the school—learning—in the face of concern that the prevalent focus on the control of disruptive behavior may not satisfy that goal (Malamuth, 1979; Winnett & Winkler, 1972). Third, there is evidence that discipline problems can be controlled by increasing academic performance (Allyon & Roberts, 1974). Fourth, problems, such as a loss of self-generated or intrinsic interest associated with external regulation (Betancourt & Zeiler, 1971; Greene & Lepper, 1974; Ross, 1975), are avoided.

A number of researchers have developed techniques to train a distractible child to either overtly or covertly condition himself to "stop, listen, look, and think" before he answers (Douglas, 1975). By changing the impulsive thoughts and actions children are able to concentrate longer and direct their attention appropriately. Blackwood (1970) found that operant verbal mediation training reduced non-attention of children who had not responded to a more traditional behavior management program. Likewise, Meichenbaum and Goodman (1971) found that this method increased concentration in impulsive children. They had two studies show that children could learn to talk to themselves and thus improve their performance on psychometric tests. Millman (1974) recommends exercises in looking and listening in order to help a child focus on the task, as he obtained positive results in this respect. Miller and Rohr (1980) indicate that verbal mediation is the most natural way to increase the learning process. They suggest that the classroom teacher utilize this technique when attempting to remediate perceptual deficits. Naming, verbal associations, and putting stimuli into verbal context have been shown to be highly effective. In general this appears to be a helpful procedure to allow a child to resist distraction in the natural environment as well as teaching him the process of giving verbal instructions to himself and thus teaching himself to learn.

Psychotherapy. The general consensus in the literature seems to be that individual or family therapy can be helpful in many respects but it is not a total program for the child who has learning disabilities and thus does not do well in school or does not listen at home. Silver, a child psychiatrist (1975), says that unless the child is in an appropriate educational program and setting the effects of psychotherapy are quickly diminished. A study done by Eisenburg in 1961 is often quoted as proof that psychotherapy does not work but this included only a total of two hours spread out over eleven weeks time.

Many researchers admit to the helpfulness of some type of family intervention. Ross (1977) and others say that these family sessions can be geared toward raising the tolerance level of the parents or other significant adults in the child's life. The general family atmosphere can be helped so that other types of intervention will have optimum effects. Louise Guerney (1979) indicates that children with learning disabilities have been receiving play therapy conducted by their parents, with positive results, at the Individual and Family Consultation Center of the Pennsylvania State University. She indicates that concentration on the deficits created by the primary problem seems to result frequently in overlooking other essential components of the development of the learning disabled. Her research suggests that Filial

Therapy can promote the parent-child relationship, reduce their own considerable stress, and improve their children's behavior.

It is difficult to review the articles using psychoanalytic therapy with learning disabled children. Some such as Brody (1964) and Gerstein (1974), have reported positive results but the length of therapy suggests there are other quicker and more efficient methods. Play therapy is usually not used for concentration problems alone but one researcher, Kissel (1975), brings in some of the cognitive mediation methods and has had good results. He says the play therapy session should be geared to teach methods for dealing with low frustration tolerance, ability to think in sequence, and orderliness. He uses model building to get these results.

Ross and Ross (1976) believe that one traditional therapy that has worked with distractible learning disabled children is brief therapy. Weakland, Fisch, Watzlawick, and Bodin (1974) have developed a brief therapy procedure that focuses on the interactions in the environment and comes in with an intervention procedure that requires a change in the behaviors that are maintaining the problem. Behavior therapists would probably say that it works based on behavior management principles.

Environmental techniques. Some psychologists and educators believe that the school environment should change to meet the needs of the learning disabled child in the areas of stimulus control and structure.

In their 1947 book on the education of brain-injured children Strauss and Lehtinen said that the biggest problem was distractibility and since this type of child was over responsive to his environment the best procedure was to reduce stimulation in the classroom. The results were said to be immediate and positive but the study lacked adequate controls. Cruickshank, Bentzen, Ratzeburg, and Tannhauser (1961) tried a similar program but there was no support for the reduction in stimulation hypothesis. Both the control and experimental groups improved so it seems that some other variable or combination of variables was working. It may have been the low teacher-pupil ratio in both groups. Other investigators have looked at parts of the minimal stimulation program such as the use of cubicles. The results here show that you do not get better academic gains (Rost, 1967) but you do get a larger percentage of attending behavior (Stephens, 1977) or increased production. The positive effect here may not be reduced stimulation but rather the positive effect of novelty that the cubicles seem to maintain. In essence, the stimulus reduction theory has been seriously questioned and in fact some people have proposed that these children are in a state of stimulus deprivation already and that they need more activity (Ross, 1977). Thus, there remains the controversy between the open classroom with lots of resource centers and the self-contained classroom.

Instead of reducing stimulation, a review of the literature seems to suggest that structure is the key word. The classroom can have many activities as long as there are consistent rules and expectations. Lessons should be structured so that the child can experience success and reward in a reasonable length of time. The home, like the school, needs to have clear-cut expectations for the child and these expectations must be within the child's capabilities. Although almost all books describing the appropriate environment for learning disabled children emphasizes structure, some of the recent work on locus of control has suggested that one should not blanketly prescribe structure.

The personality construct of locus of control is one that has received increased attention in the planning of individual learning programs for learning disabled children (Gajara, Cohen & Tarver, 1978; Tollefson, Tracy, Johnsen & Borgers, 1979). Internal-external locus of control refers to the extent to which one perceives contingency relationships between one's actions and one's outcomes (Rotter, Seeman & Leverant, 1962). In the school setting, expectancies focus on reinforcement control of intellectual and achievement-related activities. Thus pupils who believe they control school-related successes and failures are called internal pupils. External pupils, on the other hand, believe school-related successes and failures are outcomes determined by agents or factors extrinsic to themselves.

Locus-of-control theory indicates that the internal pupil should learn better in a lowly structured situation, whereas the external pupil should learn better in a highly structured situation (Arlin, 1975; Rotter, 1966). However, the methodology advocated for learning disabled students is dissonant with this position. Cruickshank (1977) has pointed out that characteristics of learning disability such as an inability to make decisions, hyperactivity, and emotional liability would indicate the desirability of a structured intervention with the learning disabled student. Because a prolonged, incapacitating disability such as a learning disability may affect the development of internal and external control orientations, Bendell, Tollefson, and Fine (1980) looked at the interaction between locus of control and the optimum degree of structure. They found that learning disabled students who were internal in locus-of-control were severely penalized in a highly structured learning situation.

Biofeedback. Biofeedback is a relatively new operant conditioning technique that utilizes some of the same procedures of self-management techniques such as cognitive mediation, but here the child obtains feedback from a machine. There are two major areas of feedback that are being used with learning disabled children. These are EMG feedback or muscle relaxation training and EEG feedback or brain wave training.

During the past few years a number of researchers have been interested in the debilitating effects of stress and muscular tension upon learning disabled children. These children manifest considerable generalized muscular tension while performing school work. In fact, one of the levels of reading recognized by reading specialists is called the "frustration level," in which a child's voice becomes more highly pitched and strained, and he begins to squeeze his fist around the book tightly; errors of repetitions, substitutions, and hesitations become more noticeable. In a word, tension of the skeletal muscles becomes so great that reading efficiency is markedly decreased.
J. L. Carter and B. Lax (1974) worked with groups of minimally brain injured children placed in special education. Prerecorded relaxation instructions were presented to groups of eight children three times a

week for four weeks. Focus for this study was upon handwriting and the results were most gratifying. The experimental group made significant gains in six areas of handwriting—including overall legibility. The gains were also found to generalize to other than treatment settings and were sustained over a six-week period. This same year Simpson and Nelson (1974) reported a study where they combined biofeedback and operant conditioning to teach children to control their breathing. The hypothesis was that once the child gained voluntary control of his breathing there should be an indirect effect on control of other behaviors. Laboratory effects were accomplished but transfer of training to the classroom was limited.

Along these same lines, S. A. Hunter and a group of colleagues (1975) found that, following training in raising fingertip temperature, learning disabled children manifested more efficient visual figure-background ability. Further, they found that learning disabled children learned to increase fingertip temperature more readily than normal controls. In another related study, L. A. Braud and fellow-researchers (1975) used biofeedback muscle relaxation training to significantly decrease out-of-seat behavior, increase school work production, and enhance general cooperation. Most recently Carter and Russell (1980) showed that EMG training on the preferred writing forearm significantly improved the academic progress of four learning disabled boys. Reading, spelling, and arithmetic scores improved significantly. They speculate that the child, while learning to control skeletal muscular tension, appears to learn experimentally that he can control his own functioning. They speculate that this learning results in some internal cognitive reorganization taking place which allows for more efficient academic learning and behavior control.

Lubar and Shouse (1977) have combined EMG training with SMR (sensorimotor-rhythm) training for controlling hyperactivity in learning disabled children. They wanted to see decreased EMG and increased SMR which is what they obtained with 3 of the 4 experimental subjects. At the end of the training the SMR records of the experimental students looked like the normal control subjects. They concluded that drug therapy plus SMR training yielded improvements better than drugs alone. Moreover, the children maintained positive results after drugs were taken away. From this study it appears that SMR training works best with the more overactive child rather than the one with a short attention span or distractibility. The one experimental subject who did not show significant improvement originally had the most SMR.

Although much of the evidence to date has centered around the use of such biofeedback procedures as EEG and EMG training for hyperkinesis (Lubar & Shouse, 1976, 1977; Shouse, 1977; Shouse & Lubar, 1978) there is evidence indicating these same procedures are useful in treating the learning disabled that may not show hyperactivity. Other studies utilizing EEG biofeedback with these children are currently underway at Joel F. Lubar's Neuropsychology Laboratory at The University of Tennessee. Harry Shabsin has administered EEG feedback to learning disabled students based on the summed or averaged evoked potentials (AEP). Corinne Bell has offered feedback to the same type student based on the electroencephalographic activity of the subjects. Both of these researchers attempted to modify or change portions of the students' brain wave activity. It is hoped that the subject's EEG or AEPs will show some degree of normalization and that this will correlate positively with behavioral changes occurring during this time within each subject's problem learning area.

Neurotherapy. Until about 20 years ago, education of children with disabilities had in general been considered a very hopeless task because most professionals believed that intelligence test scores were immutable. Moreover, exploring the possibility of changing brain functioning through educational measures was not only unpopular, but in certain countries proponents of such a theory were ostracized by their colleagues. In the fifth decade of this century a young psychologist, Bernadine Smith, showed in her dissertation that intensive teaching could change a child's capabilities as measured by intelligence tests, even of children with low IQ scores. She was expelled from the American Psychological Association. Minor errors in her dissertation were taken as proof that all her statements were incorrect. An exception to the prevailing pessimistic fatalism was the work of Maria Montessori in Rome; she was able to help most of her mentally deficient children to the extent that they were able to attend regular schools later on. However, in the United States the educational establishment expressed a great dislike for this great educator during this period of time.

Beginning in the second half of this century, however, neurological research has produced evidence that changes can and do occur in the brain, depending on the environment in which human beings live, and that even in animals brain development is influenced by environmental conditions. Not only has it been shown that brain development depends on such environmental factors as nutrition (Cravioto & DeLicardie, 1975), stimulation (Greenough, 1976), sufficient rest, absence of noxious influences, and the elusive concept for which the term love is used, but also we know at least some of the specific structural and functional changes that occur in the brain during growth and during remediation and rehabilitation of brain functions. From this information we can obtain guidance on how to conduct the educational process.

There are a number of theories (Tyler, 1978) concerning the mechanisms underlying changes in the central nervous system after brain energy:

1. When a part of the brain is destroyed, other parts may take over. This occurs in two ways: (a) either parts of the nervous system in the damaged hemisphere that had been inactive may take over, or (b) the other hemisphere may take over some of the lost functions. For instance, recovery in aphasia may occur in spite of the fact that the speech center in the dominant hemisphere has been destroyed. This is frequently the case in young children and when the injury is highly localized.

2. Synapses that have been rendered ineffective become effective and take over. Raisman and Field (1973) have shown that this occurs in subcortical areas; evidence that this occurs in cortical areas is still inconclusive (Frostig & Maslow, 1979).

3. Local tissue changes seem to be responsible for recovery, which takes place over many months or even years. The process thought to be responsible for such recoveries is referred to as "sprouting"

and consists of repair of damaged nerve circuits through the growth of new connections from the axons of undamaged neurons (Diamond, Cooper, Turner & Macintyre, 1976).

4. Development after birth in the mammalian central nervous system is marked by an enormous increase in the presynaptic and post-synaptic neuropil (the fine branchings of dendrites and axons). With development there is also increased patterning of this neuropil (Scheibel & Scheibel, 1976). The more mature patterns are marked by the bundling or grouping of the dendrites. When this pattern is disrupted, it may reform after a period of time. The Scheibels believe that the dendritic spines remain plastically reactive throughout life and can thus re-form new circuits with experience.

5. Volkmar and Greenough (1975) have shown that rats raised in an enriched environment consistently have more higher-order dendritic branching than those raised in an impoverished environment. This is but one of the anatomical and physiological differences that have been reported. The work from many laboratories strongly supports the conclusion that, at least in animals, brain structure is responsive to environmental events. The capacity for learning of the human brain is obviously the greatest in the animal kingdom; it is therefore more than probable that educational and other experiences affect its structure and that this process continues after brain injury.

6. Glial cells not only form and sustain the myelin sheaths surrounding the axons but also regulate the ionic concentrations within the extracellular space so critical for the electrophysiologic activity of neurons, provide nutrients, and carry away waste. The astrocytes,

a form of neuroglia, repair physical gaps following destruction of neural tissue (Rose, Lynch & Cotman, 1976). Neuroglia form ordered patterns of contact with neuronal membranes, thus affecting the excitability of the neuron. Hyden (1973) has demonstrated that neuroglial cells are altered in protein synthesis and enzyme concentrations in the course of learning a motor habit. Since neuroglia regenerate throughout life, their renewal, proliferation, and reorganization through learning may reestablish lost functions.

7. Changes may also occur in the extracellular structure, which consists of branching mucopolysaccharides and glycosaccarides extending from the outer surface of neuronal membranes. Changes during learning in the conductance of these extracellular channels suggest that structural alteractions in this matrix may underlie information storage and retrieval (Adey, Kado, McIlwain & Walter, 1966) and therefore can contribute to rehabilitation after brain injury.

8. Rosner (1970) has differentiated two possible mechanisms in recovery-reestablishment and reorganization. Reestablishment refers to the reappearance of the affected function. This could occur either through dissipation of diaschisis (the spread of the disturbance to unaffected areas because of shock) or through the taking over of functions by other intact structures. Reorganization would involve not only the taking over by other parts but also a reorganization of the intact structures.

9. Electrochemical changes in the synapses may permit better conduction. Rutledge (1976) has reviewed evidence relating to changes at the synapses after training and believes they may occur because of

the following events: increased action potentials, increased release of transmitter at existing synapses, prolonged excitatory postsynaptic potentials, formation of new postsynaptic membrane, appearance of new specialized receptors, and a narrowing of the synaptic cleft. Quite definite evidence is available concerning some of these changes. Garey and Pettigrew (1974) found that visual stimulation after light deprivation in kittens produced an increase in the terminal vesicle density of visual cortex axons, indicating a great availability of transmitter.

Hebb (1976) has suggested that neurons form assemblies when they are stimulated and that the impulses reverberate. Whatever makes the transmission of electrical impulses easier—dendritic or axonal branching or increased electrochemical transmitter substances or whatever—will make it easier for certain cell groups to function together when some cells in such groups are stimulated.

These neurophysiological observations and theories may explain the mechanisms of learning in the person who is well and in the person who has suffered a brain injury. All the theories state that the complex nervous pathways become functional through use. Therefore, they all imply that educational intervention can improve the functioning of the brain.

Neurotraining programs for adults are somewhat more prevalent than those for children. A clinical quasi-experimental approach to a comprehensive retraining program for the brain-injured adult was used with brain-injured men aged under 40 years including several with chronic injuries of 15-20 years duration. The longer the history and duration of injury, the less interested were the patients in the new program. Remedial services focused on mathematics, reading, writing, short-term memory, speech retraining, orientation for time and place, motor coordination, and individual and group therapy. More recently, a program has been implemented at the Hawaii State Hospital (Gudeman, Golden & Craine, 1978). The program attempts to combine comprehensive neurological assessment, based on the Halstead-Reitan Battery, with a theoretical approach to neuropsychology based on the work of A. R. Luria. From this base, comprehensive individualized neurotraining programs are designed to seek maximum recovery from neurological injury. Neuro-training, as conceptualized by these authors, differs from other remedial or rehabilitative programs in that rather than having a specific content such as reading, the procedures attempt to recapitulate the developmental sequences characteristic of the developing organism in order to reestablish basic capacities on the sensory, motor, and integrative levels. The deficits that are the focus of neurotraining are seen as ontogenetically earlier than the focus of most remedial and rehabilitative programs. This particular program showed that patients previously considered chronic and with irreversible conditions could be helped by these techniques. These authors offered two problems involved in neurotraining. First, it is difficult or impossible to structure a matched group that does not receive training primarily due to the extensive individual differences among patients with organic problems. Second, there is no single method or plan of training which may be used on every patient. The neurotrainer is faced with the task of devising new techniques for every patient.

Charles J. Golden (1979) describes a program initiated at the University of South Dakota which has as its primary goal the use of neuropsychological diagnostic information to provide services to the brain impaired child within the school and home setting. He states that the rehabilitation program is quite individualized so he does not offer what a given rehabilitation program fully entails. Nevertheless, he does indicate the ways in which they go about designing the program. The goal of the neurotherapy is to reform functional systems which have been interrupted or failed to develop because of brain impairment of some kind. In effect, this is an attempt to teach the brain to do a task in a new manner, utilizing intact areas of the brain. This is done by structuring the environment so that the person is forced to do the task using the brain systems desired and by grading the task so the child starts at a level he is able to work with. This may just involve a smaller number of stimuli, or addition of more cues in intact sensory dimensions which are slowly faded. For example, a patient with a severe parietal lobe injury lost all apparent sensation in one hand. The patient was taught to recognize the location of touch on the hand by using a visual cue (lights above the finger being touched) which was faded out (reduced in brightness)until the patient could identify touch when the lights were off. The tasks employed do not differ in substance from tasks which have been suggested in numerous rehabilitation programs. The program designed here differs in that it is providing a more effective survey of deficits and is using the knowledge of brain-behavior deficits to develop a rehabilitation program which is adjusted for the individuality of the deficits seen in each patient. The goal of neurotherapy in reorganizing these functional systems is to allow the patient to compensate or eliminate deficits caused by the brain injury. This, in turn, allows the client to function within a school, home, or work setting at his or her maximum capability, and enables the client to gain maximally from other training programs involving life or educational skills.

Reitan himself has only recently become interested in rehabilitation based on his battery of tests (Reitan, personal communication, 1979). In July of 1979 he first conducted an advanced workshop concentrating on this area. He says that he has no hard data of his own to prove that it works but that people have reported significant results to him. An extensive survey of the literature reveals that no one has documented the use of remediation materials based on the neuropsychological deficits of the children's battery. Moreover, when any type of neurotraining has been implemented it has usually been with children with brain injury rather than the more nebulous learning disabled population.

Educational Treatments

Lerner (1979) says that due to the vast individual differences among the heterogeneous group of children known as learning disabled, there are no specific educational techniques which consistently show superiority over others. Research validated studies have yet to pair the perfect material or method (Keogh, Major, Reid, Gandara & Omori, 1978; Miller & Sabatino, 1977) with a specific type of learning disabled child. The most efficient remediation effort occurs when remediation is embedded as part of an ongoing cycle of diagnosis and evaluation in terms of the child's success rather than rigid adherence to a particular theory (Salvia & Yssledyke, 1978; Stephens, 1977; Wallace & Kauffman, 1978).

There are numerous ways of classifying the remedial techniques and it seems that every author has a slightly different approach. For the purpose of this review six major categories will be explored: (1) language development systems, (2) linguistic systems, (3) psycholinguistic systems, (4) perceptual-motor systems, (5) academic management, and (6) WISC-R prescriptive programming. Studies comparing these specific techniques are at a minimum and those that do exist are generally lacking in appropriate controls and methodology. Baren, Liebl, and Smith (1978) in a recent book on learning disabilities says that special education will never be a science where methods based on research findings are consistently utilized. Stephens (1977) says that teaching practices are continued long after research has shown little positive effect because teacher education is resistant to change. Cruickshank (1978) criticizes the research and says that instead of continually finding that training in copying figures or training in ITPA categories does not consistently lead to higher academic skills, let us move on and discover what does work.

In defense of the educational researchers, it is most difficult to do "clean" research in this area. The most stringent designs that one can hope to use are those for program evaluation that are described by Stanley and Campbell (1966) in their book on quasi-experimental designs. These designs have a number of difficulties with both internal and external validity especially in situations such as a school where children cannot be assigned randomly to a design. With these limitations in mind, a brief review of the six above-mentioned categories is now presented.

Language development systems. The language emphasis approach to learning disabilities has been operating for quite some time but until recently it has taken a back seat to the visual-motor emphasis. These methods have a strong auditory orientation as they were originally developed for children with auditory receptive language disorders. This approach seems to lie somewhere between the strictly linguistic systems and the more process oriented systems such as psycholinguistics and perceptual-motor. The primary purpose is to improve language development.

There is a great deal of favorable research in the speech and language literature regarding the use of these techniques with obviously brain damaged children and adults. However, studies with learning disability children in general are lacking. Wallach and Goldsmith (1977) recommend more research to investigate the relationship between language disability and learning disability.

Three different programs representing this area are Johnson and Myklebust (1967), Barry (1961) and McGinnis (1963). Myklebust has a theory of language upon which he bases his training techniques. He presents the following hierarchy for language development:

Inner Language

Receptive Language

Expressive Language

Reading

Writing

A deficit at any one rung of this hierarchy is believed to affect all later language development. He also differentiates among the following: (1) intraneurosensory learning (one modality either auditory or visual), (2) interneurosensory learning (two or more systems must work together), (3) integrative learning (all the systems function simultaneously). A thorough and comprehensive diagnosis of the child's learning patterns is a prerequisite to determining which remedial technique must be utilized. Although he stresses the importance of the auditory language system he also includes activities that are seen in the perceptual-motor programs.

Barry's program is considered more appropriate for a much younger or more severely involved child. Although she is classified under the language systems, her activities also include psychomotor tasks. She describes her method as an ecletic approach. The program is based on Myklebust's model for language development. Like Myklebust she calls for a thorough diagnosis but unlike Myklebust she believes that every child must go through each sequence to make sure the skills have not been missed. The key word in this program is structure which is one reason it is considered good for the more involved child.

Myers and Hammill (1976) state that the McGinnis program is better designed for use with older children and adolescents. The training manual is thorough and has detailed descriptions of the methods to use. When the child has finished the three levels of the language program he is considered ready to go back to a regular classroom.

Linguistic systems. These procedures are based on the research of developmental linguists such as McNeill. Not only are there few if any objective studies comparing their effectiveness there are not a great deal of large group studies substantiating some of the claims of the developmental linguistics. One researcher did an extensive study of three children and has formulated an entire theory from these three subjects. These remedial programs put the primary interest on syntactic structure and little emphasis on semantics. Again, three programs have been chosen to represent this orientation: Programmed Conditioning for Learning (PCL), Developmental Syntax Program, and Fitzgerald-Pugh System.

The PCL program was developed by Gray and Ryan (1973) to teach spoken language to the nonverbal child. It has a behavior management emphasis and utilizes the principles of reinforcement, modeling, and schedules. It focuses on oral language responses and grammar. Most of the research has been conducted by the developers themselves. They report two studies with good gains but only one had a control group. Myers and Hammill (1976) say the method is promising but the data are not available to substantiate the effectiveness.

The Developmental Syntax Program was developed in 1972 by Coughran and Liles to be used with children who have inappropriate syntax. They use reinforcement theory to teach syntax like one would articulation rather than by a concept approach. It is not as well structured or as comprehensive as PCL mentioned above. On the other hand, it is more easily implemented in the public schools and is more economical. Like so many of the other approaches it has not been field tested.

The Fitzgerald-Pugh System was first published in 1926 but it is still applicable today, i.e., teachers still apply it. It is a predominantly visual method of teaching the structure of English to the child with auditory difficulties.

Osgood-Kirk psycholinguistic systems. All of these systems are based upon Kirk's adaptation of the Osgood communication model. In 1961 Kirk came out with an experimental model of the Illinois Test of Psycholinguistic Abilities which is supposed to effectively evaluate the level at which a child is functioning in each of the separate categories. There has been a great deal of literature attempting to prove or disprove the validity of this test. Hallahan and Cruickshank (1973) reviewed the validity studies on the ITPA and found that the literature regarding the experimental edition is inconclusive or negative regarding construct, concurrent, or predictive validity but the new edition seems to have concurrent validity. Cruickshank's (1978) conclusion in a more recent article is that the ITPA is appropriate in the hands of someone who is well trained and knowledgeable regarding its use and usefulness. Thus, these psycholinguistic programs are based upon an instrument that has been seriously questioned in the literature. Moreover, there are a group of assumptions made as follows: (1) deficits in psycholinguistic abilities are important contributions to academic failure; (2) these deficits can be measured; (3) once these deficits have been identified they can be remediated. All of these assumptions have been questioned in the literature.

There are two basic training packages. Some of those people who present a loose collection of activities with little or no sequencing are Bush and Giles (1969), Kirk and Kirk (1971), Farrald and Schamber (1973), and Velton and Sampson (1978). Others who have training materials in a kit form are Karnes (1968) and Minskoff, Wiseman and Minskoff (1972).

Criticism of the basic philosophy behind these programs has been rampant. Mann and Phillips (1967) as well as others have argued that this approach views the child as a group of malfunctioning parts rather than as a whole. They also questioned the generalization of the remediation to academic skills such as reading and arithmetic. Some writers have looked at the collection of activities and found that the level of the activities will be confused, e.g., a task may be said to represent the automatic level when it really better represents the representational level. Hammill and Larsen (1974) reviewed 39 studies using this approach and they concluded that this training is questionable. Only eight of the studies used prescriptive individualized teaching (including Saudargas, Madsen & Thompson, 1970). The majority of the eight authors reported success in training only three of the ITPA subtests: Visual association, Verbal expression, and Manual expression. There was no significant remediation of receptive language ability or automatic perceptual skills. A year later Hammill, Parker, and Newcomer (1975) did a study that was consistent with the majority of the research in this area. They found that the only subtest that correlated at all with academic achievement was grammatic closure.

<u>Perceptual motor systems.</u> These systems have been the most pervasive; in fact, at one time learning diability was synonymous with "perceptually handicapped." Today they are receiving less interest than in the past; nevertheless, in some places the entire learning disability program is based on perceptual motor therapy. There are two big categories within this area and they are delineated as follows:

Primary Motor Processes		Primary Visual-Perception
Delacatto		Getman
Cratty		Barsch
Kephart	. . . .	Kephart
		Frostig

Delacatto was described earlier under patterning and Getman is one who uses optometric training.

These systems in general believe that if a child obtains the perceptual motor competence he can then be taught by any standard teaching method. Thus, they do not include activities in the subject areas. While Frostig (1972) and Barsch (1965) mention auditory perception in passing, the others rarely mention it.

The perceptual motor area has stimulated the most research and the overriding conclusion has been that improved perceptual motor skills do not lead to better academic functioning. Some such as Johnson (1974) go so far as to say that perceptual motor abilities are resistant to training. Bortner (1974) makes an interesting important delineation in his review of the literature. He found that studies that trained skills such as copying designs were not related to academic performance, but the ones that dealt with visual discrimination tasks were. Myers and Hammill (1976) reviewed 200 studies in this area. They found only 100 that had appropriate controls and more than 10 subjects, but of the 100 studies that were left most had methodological problems. Of these studies that dealt with Kephart, Barsch, Cratty, or Getman 80% had negative results and 10% had only scanty support. A group of studies recently have questioned the promise that reversals are caused by perceptual defects (Moyer & Newcomer, 1977) or that reversals lead to poor readers, writers and spellers (Kaufman & Biren, 1977).

The two most prevalent perceptual motor programs will be described briefly. The first is Kephart which is a program that has equal emphasis on motor training and perceptual motor tasks as has been shown previously when it was included in both places of the chart showing this division. It is a process oriented approach based on the theory that remediating motor deficits will generalize to academic tasks. Treatment is based on a diagnostic evaluation using Kephart's Perceptual Motor Rating Scale. Activities include sensorimotor training, ocular control, form perception, and chalkboard training. The criticisms that have been leveled against perceptual-motor programs in general apply to this system.

The second program was developed by Frostig who has devised both a diagnostic tool (DTVP-Developmental Test of Visual Perception) and a sequence of remediation materials in visual perception. Her philosophy is that learning is primarily through the visual channel, perceptual problems are basic to learning disabilities, and visual perceptual exercises will improve learning skills. Her five areas of remediation include the following: (1) eye-hand coordination; (2) differentiation between figure-ground; (3) recognition of form constancy; (4) positions in space; and (5) spatial relations.

Frostig claims that her test has validity correlation coefficients from .44 to .50 with teacher ratings and she says this supports the test's validity. In other research the strongest evidence for validity has been based on findings of high correlation with other visual-motor performance tests. On the negative side Hammill and Wiederholt (1973) and Hammill and Larsen (1974) conclude that neither overall score or any subtest relates to reading. However, all but the eye-hand coordination were useful in predicting arithmetic achievement. Hallahan and Cruickshank (1973) criticize the test based on the normative population which was all white middle-class children. In general, many researchers refute the relation between perceptual motor problems and reading by quoting data regarding children with perceptual-motor problems who read well and children who do fine perceptually but do not learn to read.

What is even more important than the validity of the test is the results of the research using the remediation technique. Ross (1977) says that here again the available research does not show that the training helps. Myers and Hammill (1976) looked at 30 studies who had control groups and more than ten subjects. They did not screen for methodology so they claim that the results should be in favor of the program. Sixty-six percent of the studies and training did not help and 77% showed mixed results. Researchers are still plugging away at disproving Frostig. In a recent article Bassin and Breihan (1978) again found that motor activities did not improve reading.

Academic management. The recent research reports that prescriptive-diagnostic teaching is the most parsimonious and effective approach (Wehman, 1977). Working on a single skill be it visual memory, auditory sequencing, etc. does not lead to improved academic performance. With Public Law 94-142 education objectives are set forth and the best method of remediation is to include these skills within the academic areas of study. The materials that the teacher can use in academic management are in abundance, but again appropriate research regarding their relative effectiveness is lacking.

1. Reading Programs

There has been more emphasis placed on reading disability than any of the other academic areas combined. Gearheart (1976) says that research is lacking because the writers have commercial products that they do not want to disprove. Also, there is a kind of religious zeal in the writings of some regarding their own material. No single reading approach has been proven the best with learning disability children. There is a general acceptance that the child's strengths and weaknesses should be determined and that this information should be utilized in choosing the reading method. There is no way all the available methods could be covered in this paper, but below are briefly described some that are often suggested and utilized.

Gillingham and Stillman (1936) is a multisensory approach that makes most use of AVK (Auditory, Visual, Kinesthetic) rather than tactile activities. It is a phonetic approach that is suggested for use with children with visual perception problems. Based on Orton's theory of incomplete hemisphere dominance, it is a very structured time-consuming approach. There are critiques of this approach in the literature but they are based more on philosophy and intuition than research studies. Wepman (1960) says that auditory discrimination of most sounds is not achieved until the end of third grade so he is against such a strong phonetic emphasis. Dechant (1964) says that the program lacks meaningful activities and should not be used in isolation. Most recently Kline (1977) says that more research has not been done on this method due to lack of funds and lack of training. Other criticisms include rigidity, decreased interest due to lack of real reading, delay of meaningful material, and a tendency to develop labored reading with too much lip movement.

The Fernald (1943) method is a whole word approach that put great emphasis on VAKT (visual, auditory, kinesthetic, tactile). It initially involves a lot of tracing of letters and words but this is eventually faded out. It uses the child's interest in writing stories and it can be used for children with both auditory and visual problems. As with the previous method, there are many professional opinions about the positive and negative aspects but good research is lacking. Some reports have indicated that this is effective with hyperactive children especially those that are tactically oversensitive. Meier (1976) suggests, as do others, that the one-to-one situation with tutorial attention is what yields the positive results.

The ITA (Initial Teaching Alphabet) is a new alphabet so that only one sound goes with one letter. The proponents such as Downing (1978) talk about positive results with learning disability children but others question the transition to the regular alphabet once the child is reading.

The linguistic approach is a system which is neither a phonics nor a sight approach. Sounds are learned within the context of the words. Sabaroff (1977) speaks positively of this approach and says that it has not been fully utilized. As a remedial approach it is structured and often offers the fastest way for a learning disabled child to have success with reading.

2. Arithmetic Programs

Although the reading programs are emphasized more in the literature, arithmetic programs are just as important and necessary. It is not surprising that many children with learning problems have difficulty with numerals and arithmetic operations: difficulties in the memory of form direction and sequence, linked to meaningful concept; difficulties in writing numbers and organization; problems in abstraction; and confusion with the language area of mathematics (Sapir & Wilson, 1978).

"New math" with its increase of abstract terminology (associative, commutative), its horizontal presentation of simple arithmetic operations, and its rejection of memory drill may have caused additional problems for some children. The loss of memory experiences during the 3 to 8 year old stage may never be retrieved later. Many of the new developmental series of math workbooks have formats that present difficulties in organization for handicapped children because of their problems in direction and sequence. For example, when the simple addition problem of 2 + 3 is presented in this form, 2 + □ = 5, it presents seeming unsurmountable problems to some children because of the confusion of directionality, sequence and shift to functions (addition to subtraction). When it is presented straightforwardly as 2 + 3 = □, learning problems of this type do not interfere. Choice of workbooks and printed material should be made with an eye to clarity, simplicity of presentation, and careful reinforcement of early symbolization.

Some children who have severe problems with reading and/or writing may be very strong in arithmetic, but need help in language organization and writing of numbers. Some may even be superior in all phases of arithmetic computation and concepts. Many young children are helped by the use of appropriate manipulative materials and real experiences which are then translated into numbers. Older dyslexic children may be capable of doing algebraic concepts but may not have memorized the multiplication tables; memory aids should be provided for these children to allow maximum mastery. The possibilities are manifold and the good teacher, here as always, has to discover intact channels and fit the materials and methods to the needs and abilities of the child.

Many handicapped children function at a concrete level and need three-dimensional aids to assist them in computation. These are available from all the commercial companies or can be readily made by teacher and child. Selections can be based on personal preference, cost and content of the curriculum. In addition, there are programs that are built and organized to be comprehensive, individualized and concrete. Two of these are described here: Structural Arithmetic Programs and Cuisenaire Programs.

The Structural Arithmetic Program by Stern, Stern, and Gould (1965) consists of four levels from beginners to third grade, each with age related manipulative materials. This is a self-discovery method, using colored blocks representing numbers that are fitted into devices following a given sequence of experiments (Stern & Stern, 1971). In carrying out the "experiments," children discover arithmetic facts and learn how to record their findings by writing equations. The special characteristic of Structural Arithmetic is the self-teaching devices into which the blocks fit. With them errors show up immediately so that pupils learn from their errors. The rationale of the program is based on Gestalt psychology with its basic tenets: (1) learning by insight, (2) self-correction of errors, and (3) immediacy of awareness by the child. Sapir and Wilson (1978) indicate that the method is excellent but it must be left intact and continued for several years for maximum realization of its goals which are mastery of arithmetic computation and development of mathematical thinking. The revised edition of the text suggests many remedial activities for use with children having trouble with specific concepts, but the materials are necessary for their development. They are expensive but virtually indestructible. Teachers must have a good understanding of mathematics and should take at least a short training course in the use of the Stern method.

The Cuisenaire Program consists of 10 different lengths of rods that are color coded. Activities can be used for learning mathematical concepts from kindergarten to 12th grade. The rods are very versatile and can be adapted for a multiple of uses, permitting a great deal of flexibility and creativity on the part of the teacher. The value of the program is based on how it is applied and the nature of the teaching since the rods can be used as a separate program or as supplementary materials. Instructions are clear and the rods attractive. There are many workshops for teachers to become more skilled in their use. The size of the rods and the way they are organized make them difficult for the young handicapped child to explore; but they provide a very suitable support system for the older child to use in problem solving and reduce the stigma of using "babyish crutches." The lack of grade designation makes them a useful resource for the older child having difficulty (Sapir & Wilson, 1978).

3. Handwriting Programs

Children with learning problems may have trouble with handwriting for a variety of reasons. Lack of fine motor coordination in handling the pencil may cause poor writing. Visual-motor problems may lead to difficulties with formation of letters, comparative sizes, sequences and reversals. When trying to integrate thought processes and writing, the child can have severe difficulties with the mechanics. If handwriting is not taught explicitly, on appropriately lined paper with many aids and much reinforcement, it can interfere with academic functioning throughout the school life of the child. Many learning-disabled high school students persist in using printing even though it is illegible, slow and clumsy. They seem to regard printing as safer and more comfortable than script. Actually, many learning-disabled children learn script far more easily than printing. It can be useful practice to teach first graders script if printing is too difficult.

In teaching either printing or script, the two most important principles are process and pattern. The correct formation of letters must be stressed as well as the finished product. Writing must become automatic or it will interfere with thinking. Patterning strokes, i.e., teaching letters by groups having similar strokes, will help children make sense of learning and reinforce kinesthetic memory. For example, in teaching cursive writing, the letters a, c, d, and g can be taught together because of their "over and back" formation. A task analysis approach will help teachers analyze which letters should be grouped for teaching.

If remediation of cursive writing is attempted above the elementary years, the teacher has to be aware of the sensitivity of the student. Handwriting is viewed by many as part of the self and an expression of individuality. Embarrassed feelings about handwriting are often present. Some children develop a poor handwriting to hide problems in spelling and grammar. A thoughtful teacher can overcome these difficulties and correct many handwriting problems within a short period and without special materials.

WISC-R prescriptive programming. David Wechsler's intelligence measure has been used for years as a method for labeling and placing children into special programs. Oftentimes it is forgotten that the group labeled disabled via the WISC-R plus academic testing are more likely as different from each other as they are from children who are functioning adequately in the classroom. A number of resources are appearing that first of all help the resource or classroom teacher to determine the student's strong or weak learning mode based on the pattern of the subtest scores. Secondly, people such as Jacobsen and Kovalinsky (1976), Banas and Wills (1978) and Whitworth and Sutton (1978) have written books listing activities that can be used for the remediation of each of the subtests. In a recent article Wallbrown, Vance and Blaha (1979) have offered remedial strategies based on the five ability profiles they have determined from the WISC-R.

Although these prescriptive activities have been available for quite sometime and undoubtedly they are being utilized to formulate individualized education programs for learning disabled children, there are almost no formalized research studies that have documented their use and provided statistical results. Many research studies speak vaguely of including remediation techniques for short-term memory, auditory memory, language stimulation, etc., but none have strictly remediated those weaknesses found in the WISC-R profile alone.

Bradley et al. (1979) have included WISC-R prescriptive programming as a portion of a larger remediation program. The therapy program was individualized for each child on the basis of his demonstrated deficits on the WISC-R, ITPA, and selected subtests from the Detroit Tests of Learning Aptitude. The learning disabled experimental group improved significantly ($p < .05$) on 8 out of the 11 subtests on the WISC-R as opposed to no significant improvements for the learning disabled control group.

Rationale of the Present Study

Although some of the learning disabled children are helped by some of the previously described remediation techniques, there is not any one method that has been able to positively affect the broad spectrum of this population. Neurotherapy appears to be a promising area; however, very little structured research has been undertaken with the child who displays soft signs of neurological dysfunction.

Recently Ralph Reitan and his colleague Marian Selz have extended the usefulness of his neuropsychological battery for children to include a discriminative diagnosis for the learning disabled versus both normals and brain damaged. A review of the literature did not reveal any studies that have attempted to remediate LD children based on this particular battery. If the subtests of the battery are brain related behaviors, then it seems that training on these tasks could lead to improved neuropsychological functioning. This improvement in and of itself would only have practical implications if the increased skills would have a carry over effect and help the student's areas of academic deficiency.

The present study proposed to remediate the deficit areas of the neuropsychological test based on the 37 variables of the Selz and Reitan (1979) scoring system. Pre and posttest assessments included EEG, neuropsychological, and academic measurements. There are four major categories into which the results might have fallen and these are represented by the following diagram:

		Behavior	
		No Change	Change
Electrophysiology	No Change	A	B
	Change	C	D

Block A

This category is one showing no significant changes in electrophysiology as well as no significant changes in behavior (neuropsychological testing and academic testing). The conclusion here would be that remediation based on the neuropsychological testing is not an effective technique for helping LD children at least within the time frame of the present study. If the results approach the .05 level then it may be that remediation for a longer length of time would yield discrepancy between LD treatment and LD control children. Other possibilities are that the assessment measures were not the most sensitive.

Block B

Here there would be no change in EEG waveform patterns but the children would show significant improvement in behavior as compared to both a normal and LD control group. If both the neuropsychological testing and academic testing have improved then it would appear that the remediation technique is one that should be investigated further with the end result being adoption of these procedures by resource teachers in the public schools as well as people doing private tutoring. However, if the neuropsychological data were significantly improved but the academic scores do not yield as much improvement, then it would appear that the primary result is a positive increase in test data but there has not been enough generalization to academics at least within the time frame of this study. A longer remediation time might be necessary to show the academic gains. A third possibility might have been an increase in academic scores alone.

Block C

Here the children would show changes in electrophysiology but there would be no change in behavior, i.e., the neuropsychological and academic test scores would not show significant improvement compared to the LD control group. It might be that the remediation technique would change both EEG patterns and neuropsychological test data because the tasks involved are brain related behaviors; however, the academic scores would indicate that the improvement does not generalize to academic measurements. On the other hand, it may be that the dependent variables are not sensitive enough to changes in academics to take place. Another possibility was that measurable changes would take place but there was a longer latency needed for measurable effects to surface.

Block D

The fourth possibility is that the results would show significant changes in brain wave patterns as well as significant changes in neuropsychological and academic measurements. As in Block B, the positive change in behavior would warrant further investigation of the possibility of incorporating these techniques in the schools.

The purpose of the study is to explore the efficacy of a remediation technique based on neuropsychological deficits. This would be a first in a series of exploratory studies utilizing this remediation technique along with electrophysiological measurements.

CHAPTER II

METHODS

Subjects

The study involved thirteen learning disabled and ten normal caucasian male children between the ages of nine and twelve from the greater Knoxville, Tennessee, area. The mean age of the LD children at the time the treatment began was 10 years 6 months. The mean age of the normal children was 10 years 8 months. All students were from families within the lower-middle to upper-middle class in socioeconomic status.

The learning disabled children had to meet the following criteria before they could be considered as appropriate for participation in the study:

1. Diagnosed as learning disabled as a result of a psychoeducational assessment administered by the school psychologist employed in the school system.

2. Was actively participating in the learning disability resource room in his public school.

3. Was not receiving therapy, counseling or any other form of specialized services outside the school system.

4. Was free of any obvious indications of seizures, hyperkinesis, brain trauma, articulation disorder, or other severe handicaps.

5. Was not on any psychotropic drug regime.

6. As evaluated on the Wechsler Intelligence Scale for Children - Revised (WISC-R) was not scoring more than two standard deviations below the mean on the full scale score.

7. Utilizing the Selz and Reitan (1979) scoring system for the Halstead-Reitan Neuropsychological Battery, the LD children scored between 20 and 40 points.

8. The parents were interviewed and at this time they had to be willing to provide transportation for four months twice a week. They also had to indicate that they would continue to participate if their child was placed in the control group.

9. The family had no plans for moving out of the Knoxville area within the next year.

Originally there were sixteen LD children who qualified according to the above criteria. They were matched on neuropsychological severity based on the Selz and Reitan score. Then they were randomly assigned to either the treatment or control group yielding eight subjects in each group. After treatment began three of the eight control subjects dropped out from participating in the study leaving eight students in the treatment group and five students in the control group. The mean age of the treatment group was 10 years and 5 months. The mean age of the LD control group was 10 years and 8 months.

The normal children had to be those who were not experiencing any learning problems in the public school setting. They too had to be free of any serious handicapping conditions and had to be functioning at least within the normal range of intelligence as measured by the WISC-R. Their scores on the Selz and Reitan scoring system fell between 0 and 19.

Procedures

Pre- and Postassessment Procedures

1. Psychoeducational and Neuropsychological Testing

All twenty-three students were administered the following tests: Wechsler Intelligence Scale for Children - Revised, Wide Range Achievement Test (word recognition, spelling, arithmetic), Spache Diagnostic Reading Scales (oral reading and silent reading levels), Bender-Gestalt Designs, and the Halstead-Reitan Neuropsychological Battery. These tests were given by two individuals who were competent in their administration and who had no other connection to the study. They did not know if the child was being considered for the learning disabled or normal group.

Since the Halstead-Reitan Battery was used in formulating the treatment procedure in this study, the test items will be described as they are presented in the manual.

a. Category Test

This test utilizes a projection apparatus for presentation of 168 stimulus figures on a milk-glass screen. An answer panel for use by the student is attached to the test apparatus and is located below the screen. The answer panel contains four levers which are numbered from 1 to 4. The child is told that he should inspect each stimulus figure when it appears on the screen and push one of the four levers, depending upon which answer he thinks may be correct. The bell rings if the answer is correct and a buzzer is activated if the answer is wrong. Only one response is allowed for each item. Before the test begins, the subject is told that the test is divided into six groups of pictures and that each group has a single idea running through from beginning to end.

On the first item in any group the student would mainly guess, but as he continues the occurrence of the bell or the buzzer would indicate if his hypothesis is correct. In this way, the test procedure permits the subject to test one possible principle after another until an hypothesis is hit upon which is positively reinforced consistently by the bell. The first group requires only the matching of Arabic numerals. In the second group, the subject must learn to press the lever which has a number corresponding to the number of items appearing on the screen, regardless of their content. The third group is based on a uniqueness principle. The fourth group is organized according to a principle based on the proportion of the figure that is made of solid versus dotted lines. Group five is based on the same principle as the preceding group. The sixth group is not based on a single principle because it is a review group that makes use of items that have been in the other five groups. The student is told this and instructed to try to remember the correct answer for each item.

The category test is a relatively complex concept formation test which requires fairly sophisticated ability in noting similarities and differences in stimulus material and in applying problem solving techniques with the help of positive and negative reinforcement. The student requires competence in abstraction ability in order to perform well on this test. It is considered to be the best single indicator of a student's ability to function effectively outside of his protected home environment.

b. Tactual Performance Test (TPT)

The TPT utilizes a modification of the Sequin-Goddard form board. The child is blindfolded before the test begins and is not permitted to see the form board or blocks at any time. His task is to fit the blocks into their proper spaces on the board using his preferred hand. After having completed this task and without prior warning, he is asked to perform the same task using his nonpreferred hand only. Finally, he is asked to do the task a third time using both hands. The time recorded for each trial provides a comparison of the efficiency of performance of the two hands, but the time score for the test is based on the total time needed to complete the three trials. After the board and blocks have been put out of sight, the blindfold is removed. The student is then asked to draw a diagram of the board representing the blocks in their proper spaces. This drawing is scored according to memory and localization components. The Memory component is based upon the number of blocks correctly reproduced in the drawing and the Localization component is based upon the number of blocks drawn in the correct location.

The Tactual Performance Test requires a number of complex skills in order to complete it accurately. Ability in placing the variously shaped blocks in their proper spaces on the board depends upon tactile form discrimination, kinesthesis, coordination of movement of the upper extremities, manual dexterity, and visualization of the spatial configuration of the shapes in terms of their spatial interrelationships on the board.

c. Trail Making Test

The Trail Making Test consists of two parts, A and B. Part A consists of 15 circles distributed over a white sheet of paper and numbered 1 to 15. The student is required to connect the circles with a pencil as quickly as possible beginning with number 1 and proceeding in sequence. Part B consists of 15 circles numbered 1 to 8 and lettered A to G. The subject is required to connect the circles, alternating between numbers and letters as he proceeds in ascending sequence. The scores obtained are the number of seconds required to complete the task.

Trails A and Trails B require immediate recognition of the symbolic significance of numbers and letters, ability to scan the page continuously to identify the next number or letter in sequence, flexibility in integrating the numerical and alphabetical series, and completion of these requirements under the pressure of time.

d. Speech-Sounds Perception Test

The Speech-Sounds Perception Test consists of 60 spoken nonsense words which are variants of the "ee" sound presented in multiple choice form. The test is played from a tape recorder with the intensity of sound adjusted to meet the student's preference. The task is to underline the spoken syllable, selecting from three alternatives printed for each item on the test form.

This test requires close concentration and attention, auditory discrimination, and phonetic skills.

e. Rhythm Test

The Rhythm Test is a subtest of the Seashore Test of Musical Talent. The subject is required to differentiate between 30 pairs of rhythmic beats which are sometimes the same and sometimes different. The beats are presented via a tape recorder.

This test requires alertness, sustained attention to the task, and the ability to perceive and compare different rhythmic sequences.

f. Finger Oscillation Test

This test is a measure of finger-tapping speed. Measurements are made first with the subject using the index finger of the preferred hand, and a comparable set of measurements are obtained with the non-preferred hand. The subject is given 5 consecutive 10-second trials with the hand held in constant position in order to require movements of only the finger rather than the whole hand and arm. Every effort is made to encourage speed.

This test is purely dependent upon motor speed. The average times of the dominant and nondominant hands can be compared and utilized to look at the comparative efficiency of the two cerebral hemispheres.

g. Lateral Dominance Examination

This test is performed in order to obtain information regarding handedness, footedness, and eyedness. The student is asked to perform tasks that can be done using only one side or the other involving such objects as a ball, hammer, scissors, and knife. One part of this test determines which hand is used by the student in writing by asking him to write his name. This information serves as the criterion with respect to the hand used for the first trial on the TPT and Finger Oscillation Test. This name writing portion is also an important component of the overall scoring system used in this study. The examiner asks the student to write his full name in cursive but does not tell him which hand to use. The subject is not told to write quickly although he might notice that the examiner uses a stop watch to record the time. The hand used spontaneously is considered the preferred hand. Next the examiner asks that the subject's name be written in the same way but using the other hand. Again, no mention is made that the student should write quickly or in any other way alter his usual manner of writing his name. The difference in time required provides an additional indication of hand preference as well as a method of comparing the relative functioning of the two cerebral hemispheres.

h. Sensory Imperception

This procedure attempts to determine the accuracy with which the student can perceive bilateral simultaneous sensory stimulation after it has already been determined that his perception of unilateral stimulation on each side is essentially intact. The procedure is used for tactile, auditory, and visual sensory modalities in separate tests. With respect to tactile function for example, each hand is first touched separately in order to determine that the subject is able to respond with accuracy to the hand touched. Following this, unilateral stimulation is interspersed with bilateral simultaneous stimulation to the hand contralateral to the damaged hemisphere. Contralateral face-hand combinations are also used with single or double simultaneous stimulation as part of the tactile test. Testing for auditory imperception makes use of an auditory stimulus produced by rubbing the fingers lightly together very quickly and sharply. Essentially a similar procedure is applied in the visual examination with the examiner executing discrete movements of the fingers while the subject focuses on the examiner's nose. This test is obviated if the child has a tactile, auditory acuity or visual acuity problem and is not able to respond correctly to unilateral stimulation on the affected side.

i. Tactile Finger Recognition

This procedure tests the ability of the subject to identify individual fingers on both hands as a result of tactile stimulation of each finger. The child works out a system with the examiner for reporting which finger was touched since he has his eyes closed during the testing. Four trials are used for each finger on each hand yielding a total of twenty trials on each hand. The score is recorded as the number of errors for each hand. If a child has noticeably more errors on one hand as opposed to the other then it would be partial support for neurological dysfunction on the contralateral side.

j. Finger-Tip Number Writing

This procedure requires the subject to report numbers written on the finger-tips of each hand without the use of vision. The numbers 3, 4, 5, and 6 are used in a designated sequence with a total of four trials being given for each finger on each hand. Like the tactile finger recognition test, one is looking at a comparison of the two hemispheres.

k. Tactile Form Recognition Test

This test requires the child to identify flat, plastic shapes (cross, square, triangle, and circle) which when placed in the subject's hand must be matched against a set of stimulus figures that are visually exposed. The child is required to point to the shape rather than verbally name it so that the skills required remain only kinesthetic and visual.

This test is used for measuring the efficiency of the functioning of the two hemispheres. The time required to identify the plastic shapes in one hand is compared with the other. Time measurements are made for each trial and the total time required for four trials for each hand is determined.

1. Modification of the Halstead-Wepman Aphasia Screening Test

This test includes 32 items that give a rough measure of 12 different neuropsychological deficits:

1. Constructional Dyspraxia. The child is asked to copy a square, triangle, greek cross, and a picture of a key.

2. Dysnomia. The student is asked to verbally label the pictures of a square, triangle, cross, key, and a baby.

3. Spelling Dyspraxia. The words square, cross, triangle, and clock are spelled on the test as well as asking for a 5 word sentence to be written from dictation.

4. Dysgraphia. The subject must write two words as well as a sentence from dictation.

5. Dyslexia. There are 3 separate reading items made up of 4-13 word sentences.

6. Central Dysarthria. The student is asked to repeat 4 words plus one sentence.

7. Dyscalculia. There is one subtraction problem involving regrouping (85-27) and one multiplication problem (17 X 3). If the child does not succeed on these the examiner is instructed by Reitan to reduce the complexity of the problems until success is obtained. For example, 7 X 8 to 4 X 8 to 3 X 4 for the multiplication series.

8. Right-Left Confusion. There are three items relating to right-left orientation. Problems in this area can also be observed during the sensory perception tests.

9. Auditory Verbal Dysgnosia. Here the student is asked to explain the statement, "He shouted the warning." Problems would be noted here if the student has difficulty verbalizing his understanding of this combination of words.

10. Visual Number Dysgnosia. The child is required to read a set of numerals.

11. Visual Letter Dysgnosia. The requirement is to read a set of letters.

12. Body Dysgnosia. The student is asked to follow instructions involving various body parts. If he mistakes one body part for another he is considered to have a problem of this nature.

The WISC-R, although it is an intellectual measure in its own right, is also considered an integral part of the Reitan Battery. Deficits on this test were included in formulating the remediation tasks so the subtests will be briefly described in this section.

a. Information

This measures long-term memory of factual, isolated, data and may be rote knowledge or answered by analysis. It requires exposure and educational opportunities, auditory memory, sequential memory, and concepts.

b. Comprehension

This measures long-term memory of the "why" of social rules and common sense regarding personal safety and affairs. It is divided into self, family, and society as a whole. It requires exposure and experiences, information, verbal fluency, and the willingness or ability to respond to social rules.

c. Arithmetic

This measures the ability to hold orally presented details and solve orally presented math problems. It measures concentration and immediate auditory memory in a timed situation. This subtest requires arithmetic concepts, automatic and accurate number-facts recall, immediate auditory memory for details, and language visualization.

d. Similarities

This measures knowledge of relationships (concrete, functional, and/or abstract) expressed verbally from verbal cues. It may reflect inferential thinking or rote learning. Adequate performance requires experiential and educational opportunities, information regarding the nature and structure of objects, concepts of likeness and differences, and categories or concepts for larger groupings of information.

e. Vocabulary

This test measures word meanings and requires verbal fluency, information, conceptualization, and visualization. The score is influenced greatly by environmental and educational background.

f. Digit Span

This measures the ability to hold and manipulate unrelated auditorially presented digits. It tests attention and concentration and requires immediate auditory memory, sequential memory, visualization ability, and attention.

g. Picture Completion

This measures the ability to note pertinent missing details in pictures of familiar objects. It requires differentiating between essential and nonessential details in a timed situation. It also requires knowledge of the objects and their structure or parts, exposure and experience, good visual memory, good figure ground perception, and good visual functional skills.

h. Picture Arrangement

This subtest measures the ability to place pictures sequentially in causal relationships in a timed situation. It requires social awareness, common sense, perception of part-to-whole in logical sequencing, noting of details, background of information, ability to plan and organize work, and visual-motor control.

i. Block Design

This measures the ability to analyze and reproduce abstract designs with blocks from whole-to-part and reconstructing. It initially taps ability to perceive from a three-dimensional model and then from a linear model. It requires whole-to-part perception, spatial visualization, and visual-motor control.

j. Object Assembly

This task measures the ability to perceive and construct from part-to-whole with single familiar objects in puzzle form. It requires visual perception of minimal or nonmeaningful parts, perception of the overview from minimal clues, visual-motor coordination, and visual acuity in a timed situation.

k. Coding

This measures the ability to copy nonmeaningful symbols for familiar digits under time constraints. It requires eye-hand control, motor speed, short-term visual memory, visual perception for directionality of symbols, good fixation ability for keeping one's place while working, and an understanding of the code concept.

1. Mazes

This subtest measures planning ability and perceptual organization. It requires good eye-hand coordination, organization and planning, attention and concentration, and good figure-ground perception in a timed situation.

2. Electrophysiology

Electrophysiological recordings of the EEG were conducted for each subject pre- and posttreatment at the Neuropsychology Laboratory at The University of Tennessee, Knoxville. Silver disk electrodes (Grass Instrument Co. No-E5SH electrodes) were applied to each of 16 scalp positions and held in place by electrode paste. The eight bipolar pairs of electrodes were placed at International 10-20 System positions, F_3-F_7, F_4-F_8, C_3-T_3, C_4-T_4, O_1-P_3, O_2-P_4, T_5-F_7, and T_6-F_8. EMG monitoring was provided by a pair of submental muscle electrodes. Electrode impedances (measured at 10 Hz) were below 5K ohms for all EEG pairs and below 10K for the EMG.

Each student sat in a lounge chair in a sound attenuated electronically shielded room for the EEG recordings. There were three tasks that were each presented twice for a five-minute duration. These were baseline, figure drawings, and reading. For the first three tasks one hemisphere was recorded and for a repeat of the three tasks the opposite hemisphere was recorded. The order of the tasks and the order of the hemisphere recordings was determined randomly. In the baseline task the student was instructed to sit with his eyes open but as relaxed as possible. For the drawing interval the subject was asked to copy the designs from Berry's Developmental Test of Visual-Motor

Integration. The reading task consisted of reading silently from a Reader's Digest Book that was at his instructional level.

During all tasks, a red light on a panel in front of the child was illuminated whenever excessive movement (movement which would interfere with analysis of the EEG) occurred. "Excessive" was defined as EMG activity of 50 uV or greater; therefore, the red light came on whenever EMG reached or exceeded 50 uV.

Analysis of the data was accomplished through the use of a 32K word, 16 bit Digital Equipment Corporation PDP 11-04 computer with 16 channels of A to D conversion. Since only one channel could be analyzed on-line by the computer, the other three were recorded on a Teac R-7 FM tape recorder. They were played back, one channel at a time, for analysis. The computer performed on-line Fast Fourier Spectral Analytic transforms of all recording channels and produced quantitative and pictorial compressed spectral arrays of the EEG in the form of tables and graphs.

Treatment

The five learning disabled control children did not receive any specialized training procedures between the administration of the pre- and postassessment measures; however, like the treatment subjects, they continued to receive resource assistance in their school.

The treatment children received 40 minutes of individualized remediation twice a week over approximately four months for a total of 32 sessions. Appointments were set for after school hours and on Saturday so that there was no interference with the regular school program.

The general teaching approach incorporated a number of techniques presented in the literature for working with learning disabled students (Velton & Sampson, 1978; Cruickshank, 1977; Farrald & Schamber, 1973). The following approaches were utilized:

Showmanship

Showmanship is important and was utilized by the therapist in this study. Mood (1970) in a review of available research on how teachers make a difference in pupil achievement notes that a number of clues point to the likelihood that acting, directing, animation, and staging may become an essential part of teaching. He notes that educators can no longer serve as a welcome relief for children burdened with arduous chores at home or on the farm. Nowadays schools are dull compared to other sources of learning such as television. Unless the teacher develops showmanship and becomes an animated ham, children may "switch to another channel" or "tune out."

Avoiding Impulsive Behavior and Verbalization

These students often speak and act impulsively. In order to make the 40-minute sessions as consistent across subjects as possible, some ground rules were established. The therapist allowed up to five minutes of sharing time before therapy began. After this a timer was set for 40 minutes. The students soon learned that irrelevant verbalizations were ignored. During the first five sessions the student was allowed to ask how much time was left without penalty only once. After the five sessions or single request the therapist added another two minutes to the timer. The logic of this procedure was explained to the child in terms of the amount of time that is lost by such an interruption. This system was so effective that only 9 times out of a total of 256 did the additional time need to be added. At the end of the session time again was allowed for extraneous thoughts the student had during therapy.

Structure

Many researchers cite evidence that structure is a salient characteristic of a program for the learning disabled (Velton & Sampson, 1978). Lesson plans were written for each session with activities numbered and ordered in the manner they would be presented. The student was able to look at the list and note the procedure of checking off each item as it was completed. The therapist made notes to help formulate the plan for the following session. With this procedure, the child was thoroughly aware of exactly what was expected for the 40-minute time period.

Frequent Change of Activities

Each subject would have a lesson plan that would consist of 12-20 different activities; thus, catering to the documented short attention span of learning disabled students. Similar tasks were not juxtapositioned in order to avoid confusion. These activities appear in the Materials section.

Success Oriented Activities

Motivation springs from success and lack of motivation results from failure. Cruickshank (1977) states that the curriculum should be set up so the learning disabled child can be correct at least eight or nine times out of ten. Thus, the activities in this research were carefully planned so that success was expected 75-80% of the time. The student's performance on tasks in previous sessions were carefully analyzed and were used as a basis for taking the student to more difficult tasks in small steps.

Frequent Review

Learning disabled children often have weak memorization ability; thus, they may correctly read or spell a word one day as a result of intensive instruction but often will not know the same word even the next day. Because of this characteristic each lesson included one or two review items from previous sessions. These would be items that were performed without error earlier but which needed instruction to reach success.

Appropriate Instructional Materials

Materials for the learning disabled should be individualized and concrete. Teacher-made materials utilized colorful borders of bright colored construction paper so that this would set limits to the task. Effort was made to present items in a simplified manner to cut down on directional confusion. A dark felt marking pen was used to assist in combating figure-ground problems.

Treatment activities were based upon the individual items of the Halstead-Reitan Neuropsychological Test Battery. Each student's performance on the test was analyzed using the Selz and Reitan scoring system. In this system there are 37 categories and scores range from 0 to 3 on each category. A 0 score means no deficit and a 3 indicates significant impairment (see Table 1, p. 18). From this scoring system was obtained a list of the student's neuropsychological deficits in order of severity. The subtests from the Wechsler-Revised are included in the scoring system only in reference to the degree of scatter among subtests as well as the overall intelligence scores. For purposes of remediation subtest scores of 9 and below were considered weaknesses and were included in the treatment program.

Below is a list of the possible deficit areas that were included in the remediation goals for each of the eight treatment students:

1. Category Test (abstract thinking, categorization, problem solving, concept formation).
2. TPT (kinesthetic spatial organization including a memory and localization component, tactile form discrimination).
3. Trails A (dot to dot by number, recognizing symbolic significance of numbers).
4. Trails B (flexibility in integrating the numerical and alphabetical series).
5. Speech Sounds Perception (word recognition, phonics).
6. Seashore Rhythm (auditory discrimination and memory).
7. Finger Tapping (motor dexterity and speed).
8. Name writing with preferred hand as well as the difference in performance between preferred and nonpreferred hand.
9. Tactile Finger Recognition (ability to identify individual fingers on both hands as a result of tactile stimulation).
10. Finger-Tip Number Writing (ability to recognize numbers written on the finger-tip).
11. Tactile Form Recognition (tactile form discrimination).

12. Constructional Dyspraxia (copying designs, visual and spatial organization).
13. Dysnomia (inability to retrieve the names of objects).
14. Spelling Dyspraxia (inability to spell).
15. Dysgraphia (inability to write accurately).
16. Dyslexia (inability to read at the expected level).
17. Central Dysarthria (speech articulation problems).
18. Dyscalculia (inability to compute math problems).
19. Right-Left Confusion.
20. Auditory Verbal Dysgnosia (inability to explain the meaning of a sentence).
21. Visual Number Dysgnosia (difficulty with reading numbers).
22. Visual Letter Dysgnosia (difficulty with reading letters).
23. Body Dysgnosia (confusion of body parts).
24. Vocabulary (defining words).
25. Social Comprehension (appropriate responses to social situations).
26. Similarities (abstract thinking, categorizing).
27. Arithmetic (word problem administered orally).
28. Digit Span (short-term auditory memory).
29. Information (general fund of factual knowledge).
30. Picture Completion (visual alertness).
31. Picture Arrangement (sequencing).
32. Block Design (visual and spatial organization).
33. Object Assembly (puzzles).
34. Coding (short-term visual memory).
35. Mazes (planning ability).

Materials

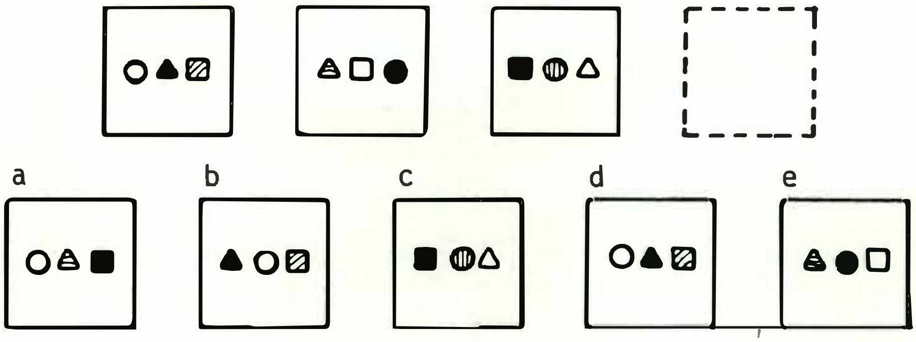
Activities for remediation of the 35 categories above were developed. In no instances were the Reitan 9-14 Battery or WISC-R materials themselves used for the training. Commercial products were obtained from school supply stores as well as various toy stores. Other materials were made by the author. Following is a complete list of all materials used in each of the 35 categories listed above. If the materials were purchased the manufacturer will be listed and the address will appear at the end of the Materials section. Many of the ideas for remedial tasks for the WISC-R came from other sources who have compiled books on this subject (Farrald & Schamber, 1973; Kovalinsky, 1976; Banas & Wills, 1978; Whitworth & Sutton, 1978). On the other hand, the activities devised for remediation of the Reitan Neuropsychological Battery were created by the author.

Category Test

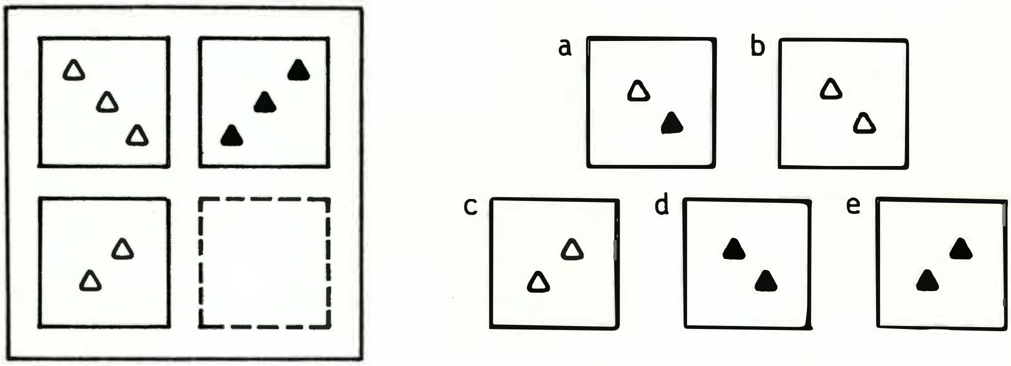
1. Four nonverbal tests were used as models for the therapist to make materials that would involve problem-solving tasks with visual material. These tests were Cattell Culture - Fair Test, IPAT Culture Fair Intelligence Test (Scale 2), the Leiter International Performance Scale, and Raven's Progressive Matrices. For examples of these items see Figure 1.

2. Since these children were administered the Reitan Battery for 9-14 year olds, the category portion of the younger battery (5-8 year olds) was used for remediation. The same apparatus is used but the buttons have the four primary colors rather than the numbers 1-4. The

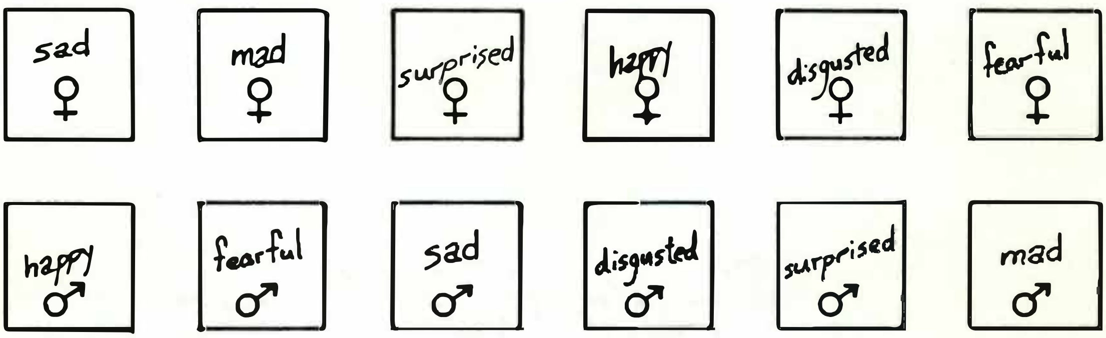
Example 1: Which one comes next?



Example 2: Which one fits?



Example 3: Match these.



Example 4: Which one fits?

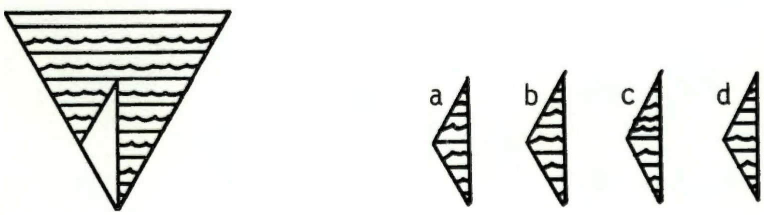


Figure 1. Examples of Problem Solving Tasks with Visual Material.

test consists of 80 slides. The first group requires the student to match colors so that if a red figure appears on the screen the subject should respond by depressing the "red" lever. The second group of items is based on the idea of quantity and the child is supposed to respond to the predominant color. If a large red square and a small blue square appear the answer is in terms of a predominant quantity with respect to the area. The third group of items is based upon an oddity principle. Thus, if an item consists of four squares in which three are identical in size but the red square is larger than the rest, the answer would be the "red" lever. The fourth group of items requires the subject to respond to the color that is less prominently displayed than the others. The fifth group consists of ten items that have appeared before and the child is instructed to try to remember the right answer and give the same answer again.

3. A game of dominoes was made by the therapist whereby the student had to match the Arabic numeral with the Roman numeral. The Roman numerals I-XII were included on the dominoes.

4. Cards were made in groups of 15 that were representative of the principles utilized in the Category Test: quantity, uniqueness, and the proportion of the figure that is made of solid versus dotted lines. Each of the groups included cards in sets of five rather than sets of four that appear on the test itself. For examples of the uniqueness set see Figure 2.

Tactual Performance Test (TPT)

1. A number of materials were used to duplicate the procedure of the TPT. As in the test, the student was blindfolded. He was asked

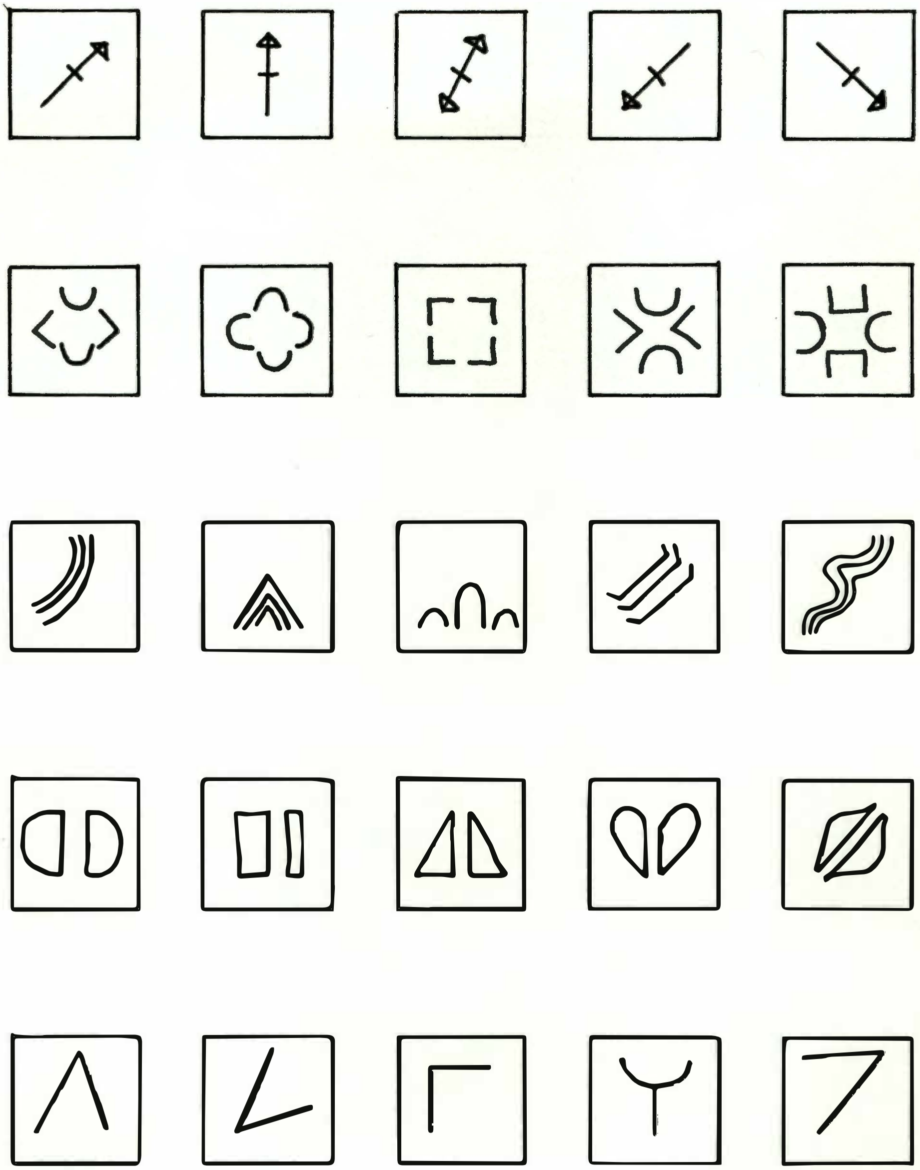


Figure 2. Examples Similar to the Category Test.

to perform first with the dominant hand, then the nondominant and then both. The time for each performance was measured. Then he was asked to reproduce the materials by drawing the shapes. The following commercially produced products were used:

a. Form Board (Playskool)

b. Blue Form Board from Bayley Infant Scale

c. Pink Form Board from Bayley Infant Scale

d. Wooden Fit'n Form Attribute Puzzles (Playskool)

e. Single Form Puzzles (Playskool)

   1. Fruits

   2. Things that Fly

   3. Farm Animals

   4. Colors I See

f. Jumbo Fit-A-Letter Capitals (Lauri)

g. Junior Fit-A-Space (Lauri)

h. Fit-A-Space (Lauri)

2. Using the Lauri materials called Feel and Match - Thickness the child was blindfolded and asked to match the thicknesses. There are 12 3 1/2-inch discs of crepe foam rubber in six different thicknesses.

3. Sandpaper letters and numbers were made. The student was asked to put one hand or both under the table and a sandpaper letter or number was handed to him for identification. Three sets were made varying in sizes of one, two or three inches so that finer and finer discriminations were necessary.

4. A shopping bag was filled with ordinary items that could be recognized by touch and the student was asked to reach in and feel the objects one by one. Descriptive language was encouraged in describing

what they felt. The hand that showed the deficit on the TPT would typically be used. Another method was to have the objects identified by one hand one session and the opposite a following session. Both hands together could be used when the kinesthetic problem was severe. Example items are fruits, vegetables, toys, pieces of cloth, and wooden or plastic forms.

Trails A

1. Dot to dot books are readily available in any drug or dime store. Each subject had their own book that included dot to dot by letters as well as numbers. For those students showing deficits in this area five pages were completed each session and a stop watch was used to time each performance. These students also were asked to do ten pages for homework with their parent timing them. For those boys who obtained a nondeficit score, one page was completed during the session and five were done at home.

2. Commercially produced wipe off cards by Trend Enterprises were used during the session only for those showing deficits.

a. 20-40 Dot to Dot.

b. Counting by 2's Dot to Dot.

c. Counting by 5's Dot to Dot.

d. A-Z Dot to Dot.

Trails B

1. The Color Form Test from the Reitan-Indiana Neuropsychological Test Battery for children was used in remediation because it is one of the tests for the 5-8 year olds that taps the same skills as Trails B. The Color Form Test uses stimulus material of various colors and shapes.

The child's task is to follow a sequence of progress from one figure to another on an 8 1/2 x 11" page, making the first move on the basis of shape, the second move on the basis of color and so forth. Thus, the subject moves from the initial figure to one having the same shape even though the color is different, then proceeds to a figure that is different in shape but has the same color, and continues to alternate in this fashion. Essentially, the test requires the subject to make progress from the beginning to the end of the test, alternating form and color criteria in much the same way that Part B of the Trail Making Test requires alternation between numbers and letters. Using this same idea, more complex materials were made with 12, 14, 16, 18, 20, 22, and 24 shapes.

2. The Progressive Figures Test from the 5-8 year battery was also used. It is somewhat more difficult than the Color Form Test (see Figure 3). This test is also presented on an 8 1/2 x 11" sheet of paper on which are printed eight stimulus figures. Each stimulus figure consists of a large outside figure (such as a circle) and a smaller figure of another shape inside (such as a square). The subject's task is to use the small inside figure as a clue for progressing to the outside shape of the next stimulus figure. For example, if the subject is located at a large circle enclosing a small square, the small square would indicate that the next figure to move to would be the one having a large square. If the large square enclosed a small triangle, the small triangle would serve as a clue for the next move. In this way the subject progresses from inside figure to outside figure, moving from one stimulus complex to the next. Using the same idea, additional materials

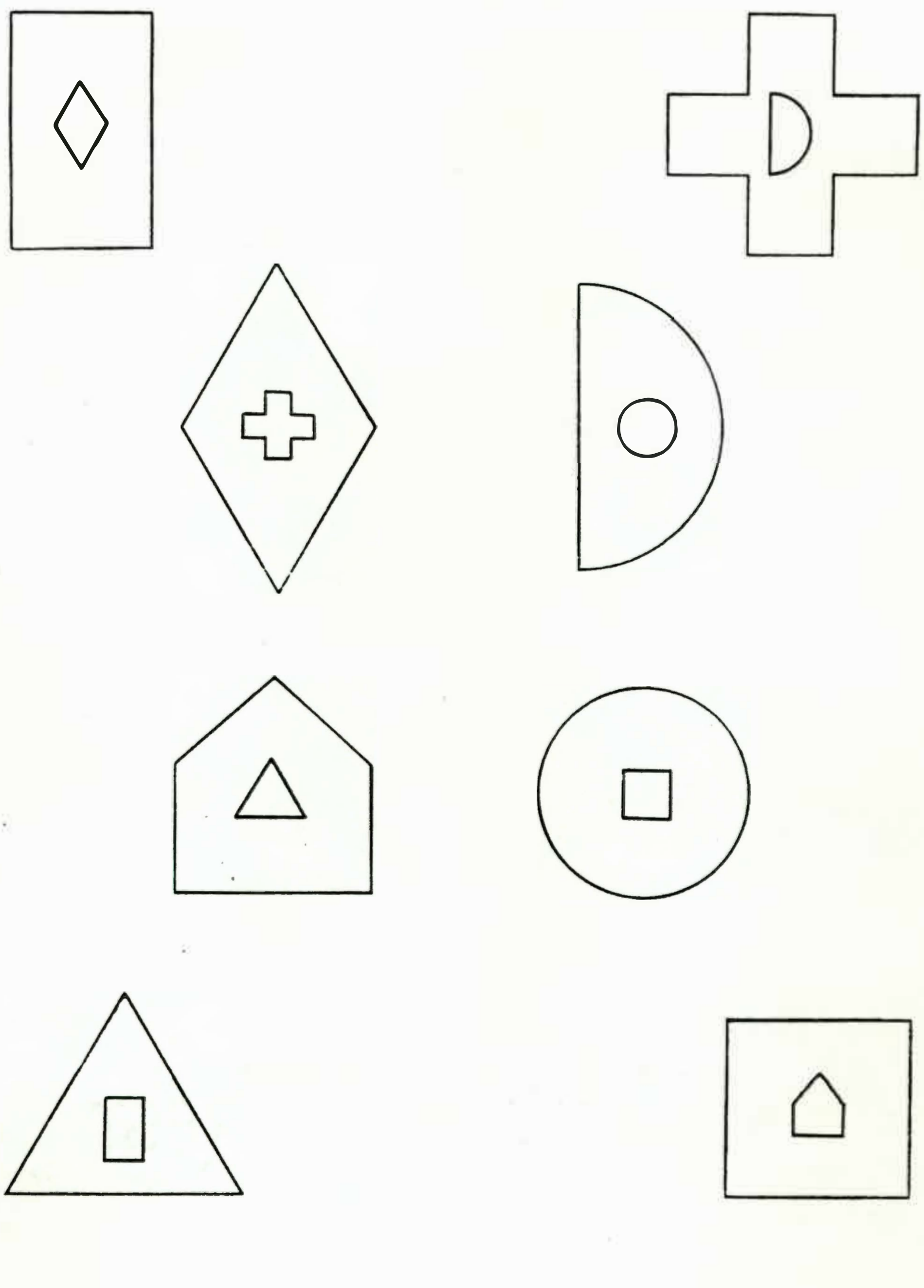


Figure 3. Progressive Figures Test.

were made with 8, 10, 12, 14, 16, 18, 20, 22, and 24 items. Three examples of these are seen in Figures 4, 5, and 6.

3. A series of activities were devised by the author whereby the student would have to integrate numbers with categories of the items. An example of one of these is seen in Figure 7. Here the student was instructed to alternate animal and fruit while also utilizing the numbers one to six. He was directed to use verbal cues such as "one animal, one fruit, two animal, two fruit, three animal, three fruit" and so on to the end. More complex materials went up to as high as ten coupled with four categories of pictures.

4. Two varied approaches to the idea of alternating numbers and letters were developed. In Figure 8 the student was expected to alternate from letters to a series of dots representing the numbers. In Figure 9 alternating was expected from alphabet letters to Roman numerals.

Speech Sounds Perception

1. Lists of 10 rows of words were made with four choices each. These were mounted and laminated. The words represented combinations of familiar syllables that appear on the Spache Diagnostic Scale. See Figure 10 for two examples. Cassette tapes were made to go along with each set of words. It can be noted that four different tapings were necessary to include all four possibilities in remediation. As the student listened to the tape he could either point to the correct word or mark it with a grease pencil. There were 16 sets numbered A to P.

2. Another set of laminated lists were made including primarily nonsense linguistic combinations preceded by a constant. Examples are

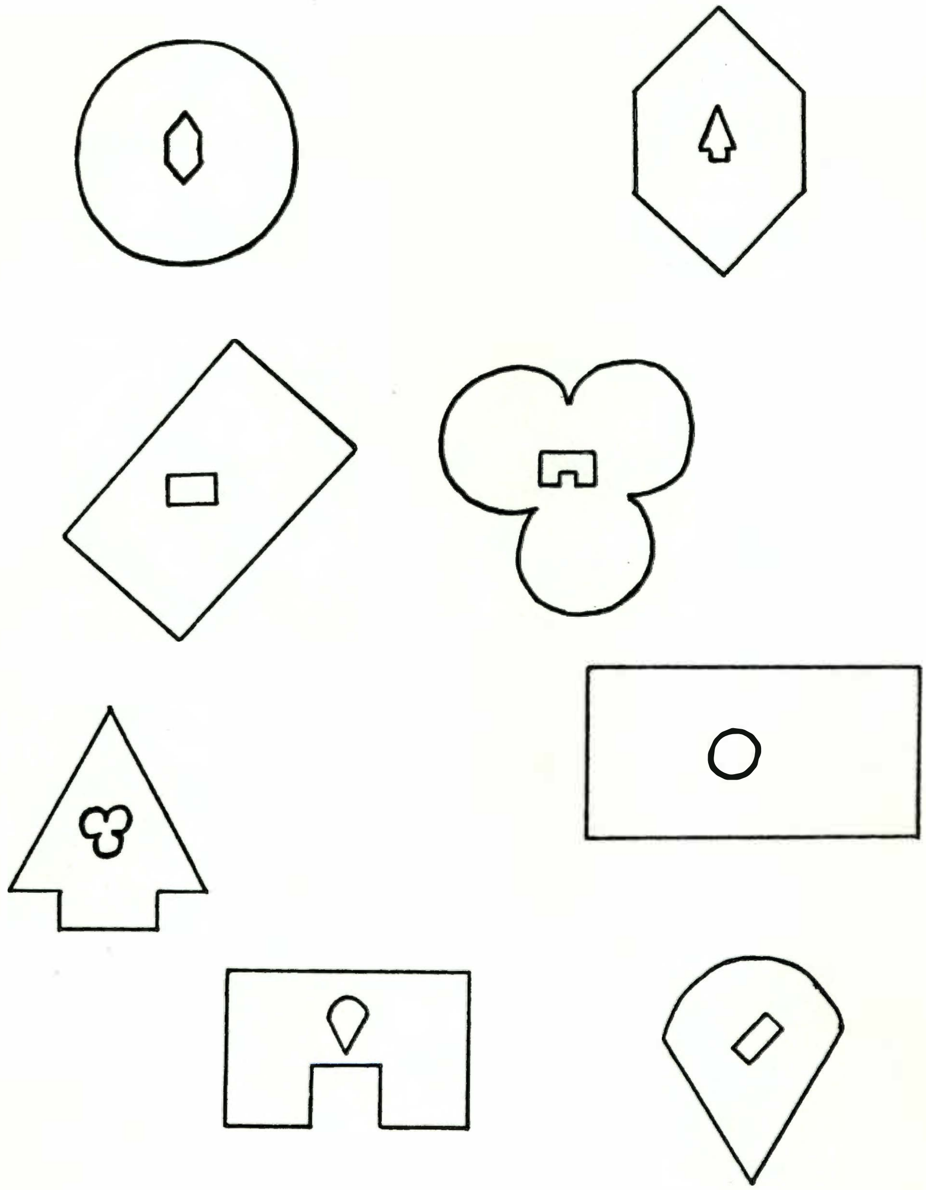


Figure 4. Example of Progressive Figures Test with Eight Items.

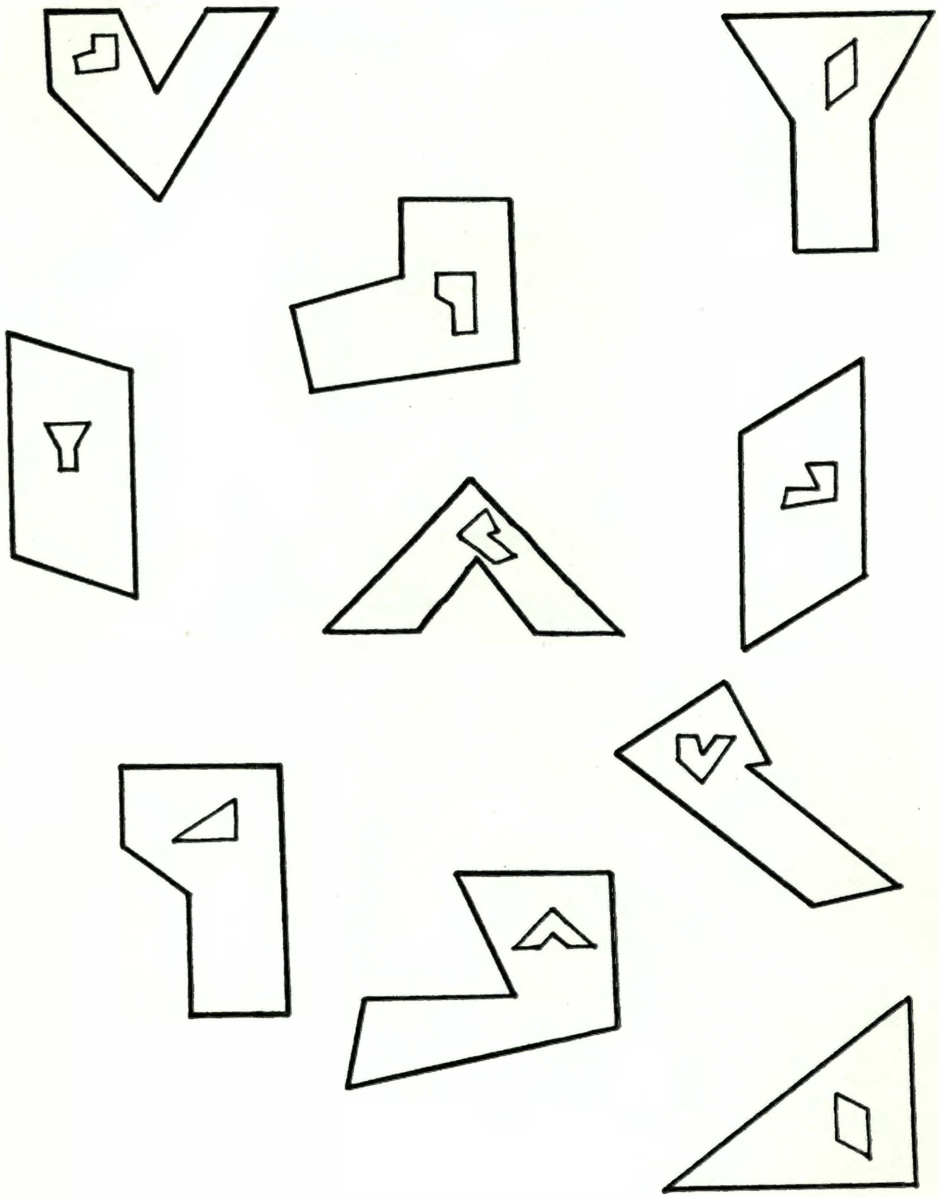


Figure 5. Example of Progressive Figures Test with Ten Items.

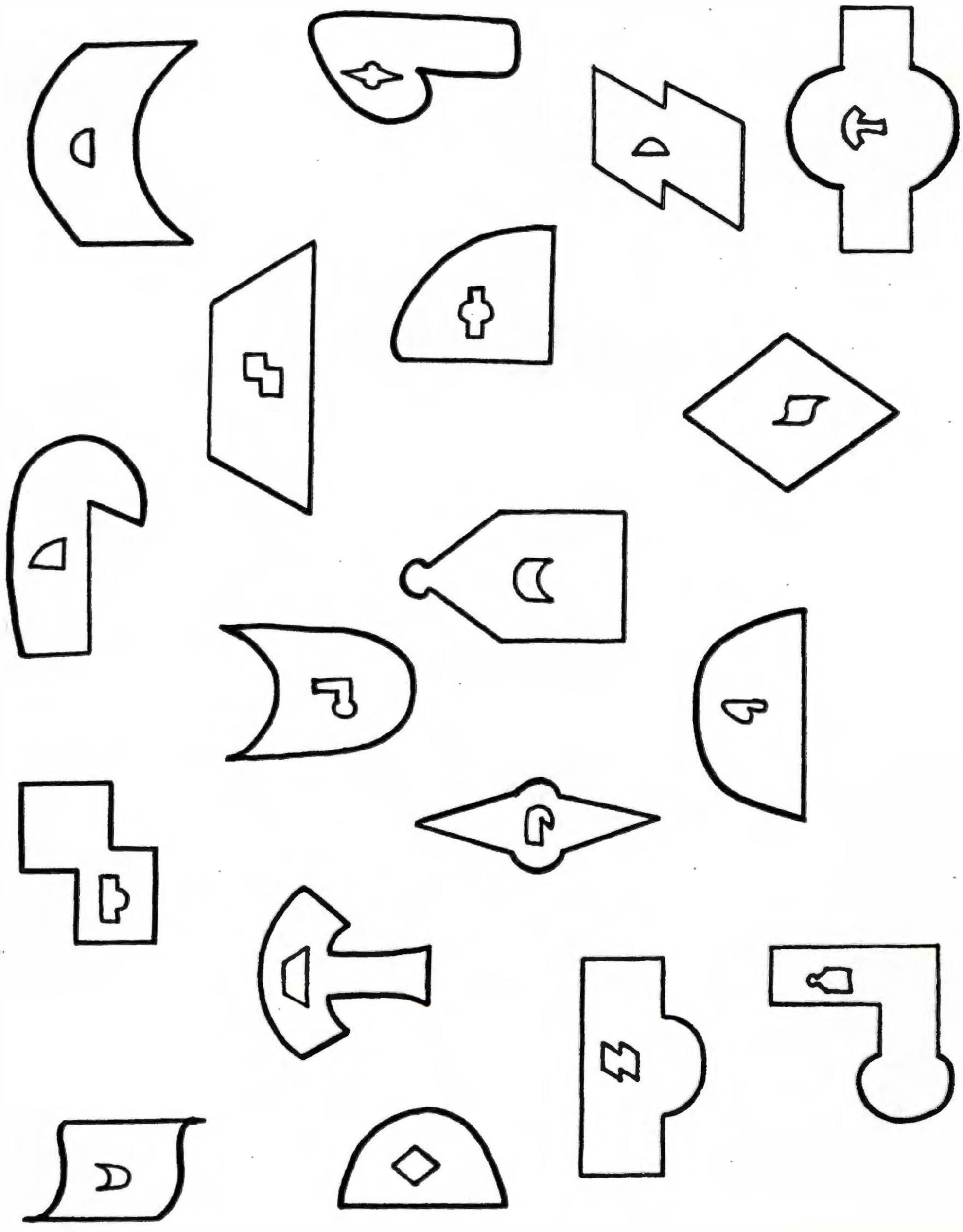


Figure 6. Example of Progressive Figures Test with Eighteen Items.

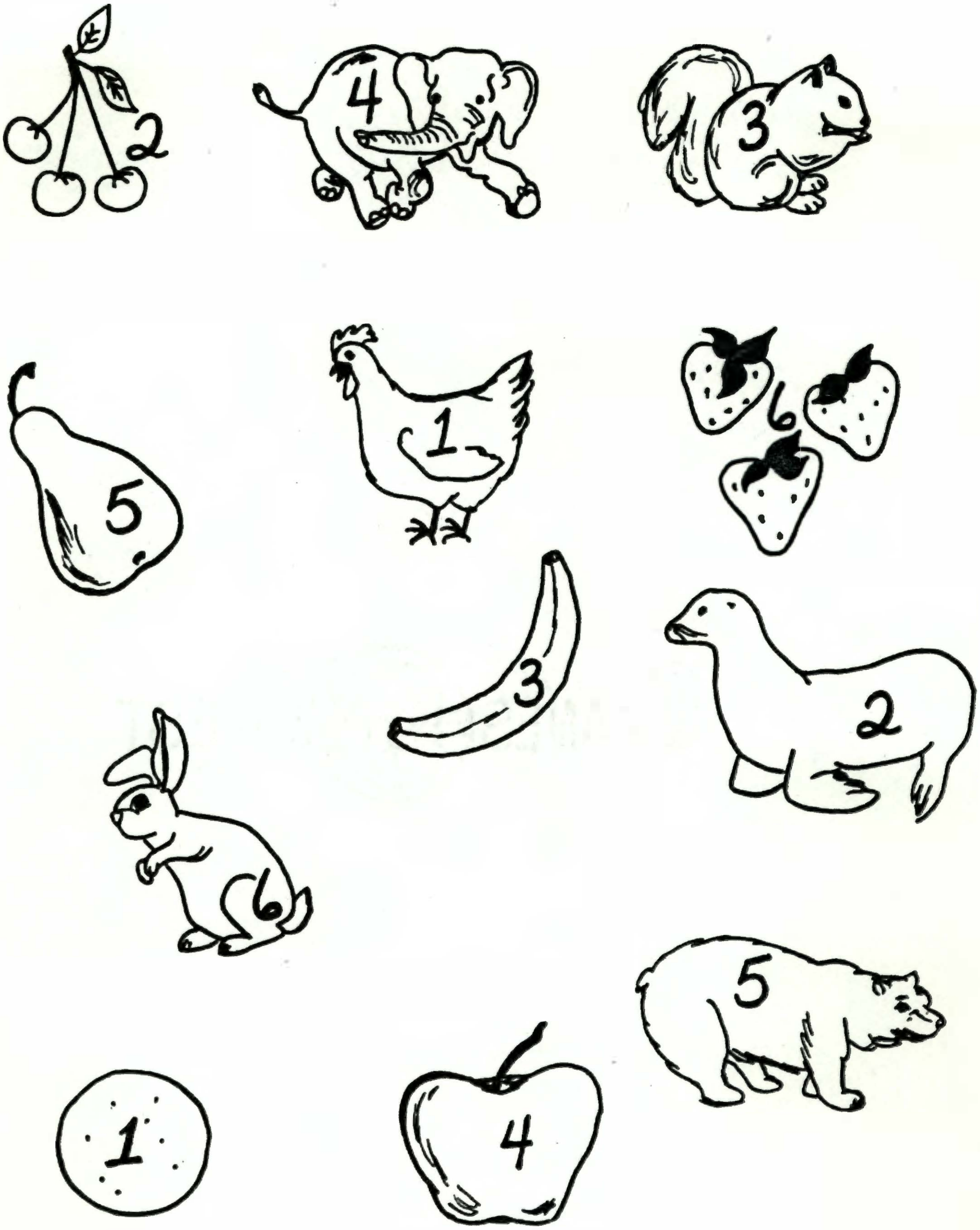


Figure 7. Example of Trails B Alternating Categories.

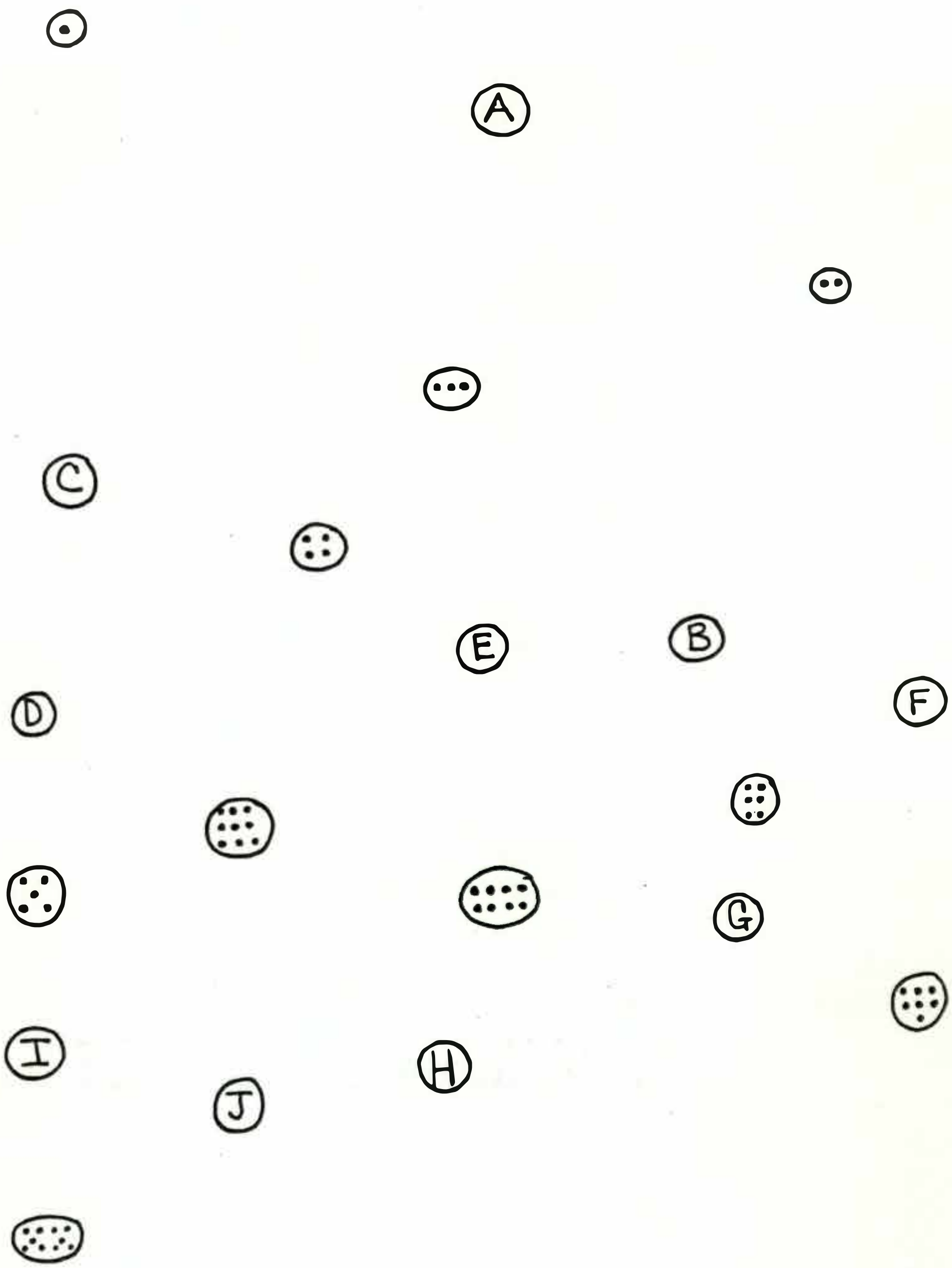


Figure 8. Example of Trails B Alternating Letters and Numbers.

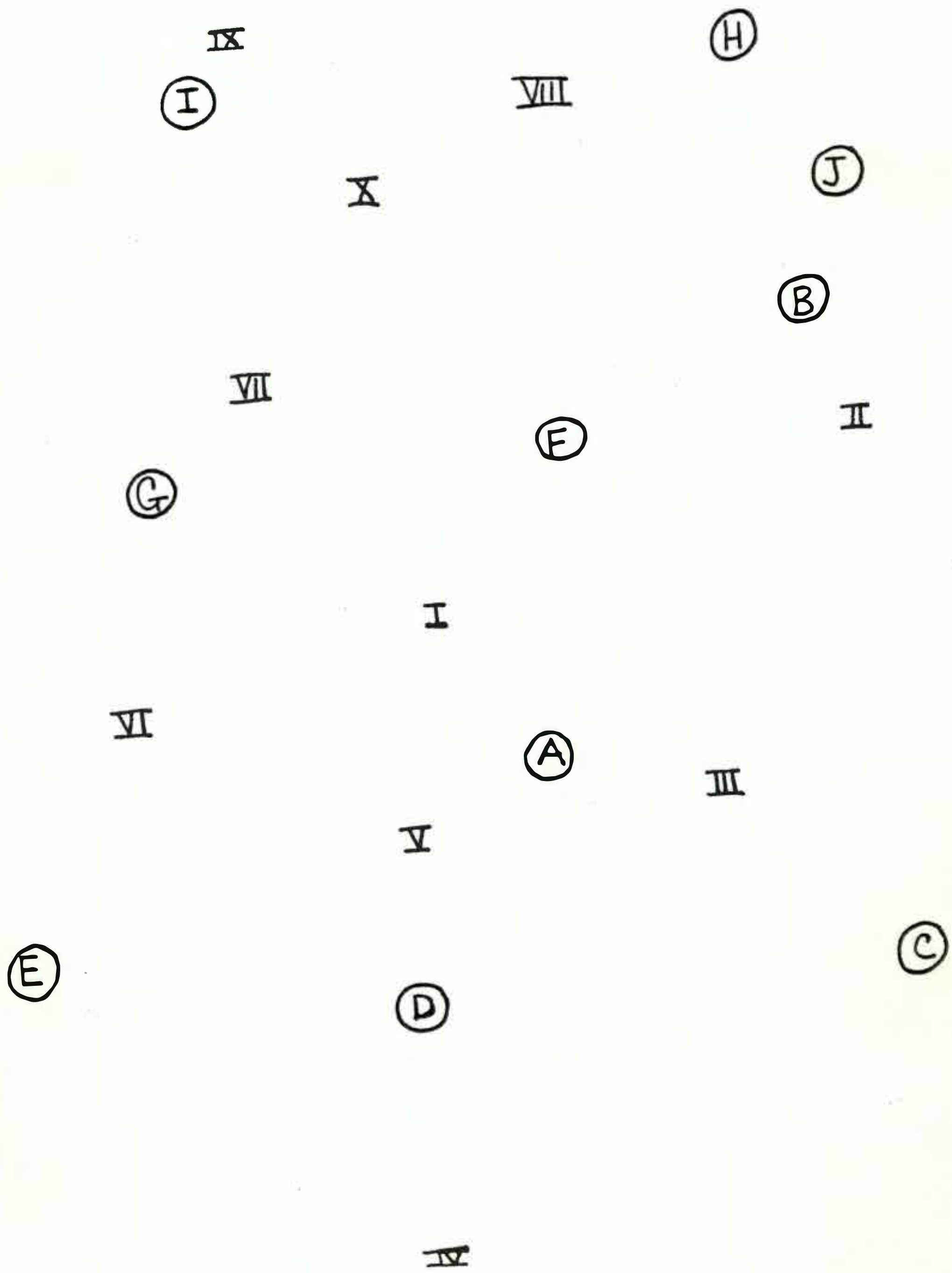


Figure 9. Example of Trails B Alternating Letters and Roman Numerals.

ake	ache	ace	ach
ill	ell	ile	ele
di	de	da	do
al	ale	owl	el
ight	ite	it	ait
ent	unt	int	ant
ide	id	aid	eid
ock	oke	oak	oik
ick	ec	ek	iec
on	en	in	un

est	ist	es	east
ate	at	et	eat
er	ir	ur	or
ay	ah	eh	ey
ite	it	eit	et
con	cun	cen	can
it	et	ut	ot
ain	ane	ean	an
ing	eng	ung	ong
ed	id	ad	ud
and	end	ind	und

Figure 10. Examples of Syllables for Speech Sound Perception.

the following combinations with only the i sound: ir, ig, it, ib, id, ite, ip, ik, ill, im, in, is and iv. The lists each had 17 rows with four choices each (see Figure 11). Cassette tapes were made to present the choices to the students.

3. A third set of nonsense words was made similar to those found on the test itself but including a variety of vowel sounds rather than just the long e sound. Each list had 10 words and was accompanied by a cassette tape. Twenty-five percent of the time the therapist would pronounce the words herself to the student in place of the recording.

4. A set of flash cards were made with small words that are frequently confused by learning disabled students. An example set consisted of the following: then, that, they, this, there, than, their, the, thus, and here. The student had to recognize whether the word spoken by the therapist was the same or different from the word on the flash card.

Seashore Rhythm

1. Xylophone patterns were recorded on tape in sets of ten pairs. The student was required to respond with an S for same or D for different. This required auditory discrimination of various tones.

2. Tapes were made by tapping out various pairs of rhythms on the xylophone but using only one note. This required a same or different response based on auditory discrimination of various rhythms. Additional tapes were made by tapping on a desk with a xylophone hammer and also by hand clapping.

3. A cassette tape was made with clapping rhythms. After a trial the student was given time to write down the number of taps he heard and

vur ver vor vir var
tor tur tar tir ter
rer rir rar ror rur
war wer wir wur wor
dar dir dor dur der
far fer for fir fur
pur per por pir par
gar ger gir gur gor
sar sir sor sur ser
nir nar nur ner nor
har hir hor hur her
jir jur jer jar jor
kir kar kur ker kor
mur mer mor mir mar
bir bar bur bor ber
cer cur cir car cor
lur ler lor lir lar

Figure 11. Example of Nonsense Linguistic Combinations for Speech Sounds Perception.

then the correct answer would be on the tape thus providing immediate feedback. After the number was offered the same pattern was clapped so if a mistake was made the student could hear the pattern again.

4. While the student was turned away from the therapist, two notes from a large wooden xylophone were played and the task was to say if they were alike or different. After this was mastered combinations of two notes, three notes, etc. were offered and the same response was required.

5. The therapist stood behind the student and bounced a ball or snapped her fingers a special number of times. The student would respond with the number of bounces or snaps he heard. The sounds were produced in uneven patterns.

6. The student with his back turned and eyes closed was asked to identify different sounds:

a. Door opening

b. Pencil sharpener

c. Paper crumbled

d. Paper torn

e. Drawer opening

f. Chalk on chalkboard

g. Dialing on the phone

h. Tapping foot on floor

i. Clapping hands

7. The therapist would say a word and the student would have to do one of the following: (1) say a word that rhymes with it, or (2) say a word that begins with the same phoneme, or (3) say a word that ends

with the same phoneme, or (hardest) (4) say a word that does not rhyme but has the same phoneme in the middle, e.g., hat-man.

8. Using Rhyming Pictures by Ideal, the student was asked to sort the words into rhyming piles. The activity was timed and recorded on a number of sessions.

9. Lists were made similar to the Wepman Auditory Discrimination Test which consists of a series of word-pairs. The student was turned around from the therapist and was instructed to say whether the words were alike or different.

10. The student was asked to identify words as same or different after listening to recorded words having like and unlike consonant or vowel sounds in initial, medial, or final positions.

Finger Tapping

1. The electric finger tapper from the Reitan battery that is used only for the 5-8 year old children was utilized in this remediation program to help the child develop motor speed with the finger that was showing a deficit according to the testing.

2. The Basket-Bounce game (Model No. 186) by Smethport was used to strengthen the weak side for tapping. This game has a lever on each side so that baskets can be shot with either hand. If the student was slow with his left hand, the therapist would shoot with the right and let the student use the other side. Sometimes the child would play his right hand against his left if he needed to strengthen both sides.

3. The Professor Egghead game (Model No. 213) by Smethport was used in the same manner as the Basketball game except that the student would always use both sides himself in attempting to get the professor's marbles in his head.

Name Writing

1. Laminated sheets were made with the student's full name written in cursive so that the student could trace over it with a grease pencil. Room was also left so that the student's name could be written five more times on the laminated sheet.

2. Each student practiced his name with both his dominant and nondominant hand but the amount of time spent with one versus the other was determined by the severity scores on the Selz and Reitan scoring system.

3. The student was asked to write the alphabet and the numbers 1-100 with the deficient hand.

4. The student was asked to take dictation in cursive with the deficient hand.

Tactile Finger Recognition

1. The procedure of tapping the fingers was used in remediation as it appears in testing except that the student was allowed to see the tapping. The only response he had to do was to name the number of the finger that was tapped.

2. Another method was to not let the child see the tapping and to ask for a response that consisted only of picking up the finger that was tapped.

3. The finger procedure was transferred to the feet in the same manner as the hands. The student had to respond verbally with the number of the toe that was touched without having seen the stimulation.

Finger-Tip Number Writing

1. The numbers 1-10 were written in varying order on the student's palm when he had his eyes closed. He was required to report the number he felt.

2. The numbers 1-10 were also written on the back of the hand and the task was to recognize and report the number.

3. The numbers 1-10 were written on the student's back. They were presented on either the right side or left side of the back.

4. The numbers 3-6 were written on the child's right or left calf and a verbal report was required.

Tactile Form Recognition

1. The Jumbo Fit-A-Letter Capitals (Lauri) were handed to the student under the table. He was required to tactilly examine it with his deficient hand and point with his other hand to the correct letter from a list of letters. Those letters he had trouble with were recorded and offered for examination again in a following session.

2. A variety of geometric shapes were cut out of poster board and laminated. Two of each shape were made. One set was placed on top of the table and the other set was handed one by one to the student. He had to nonverbally respond by pointing to the matching shape on the table.

3. A variety of animal shapes were cut out of poster board and laminated. The same procedure was used as with the geometric shapes.

4. Ten objects were placed in a shopping bag with duplicates of the ten objects placed on the table in front of the child. He was instructed to feel one object, point to its counterpart on the table,

remove the object to see if the match is correct, and then place the object back in the bag.

Constructional Dyspraxia

1. Clear stencils by DLM were used with those who had difficulty making a square, triangle, or diamond.

2. The student was asked to copy designs from the Perceptual Development Cards (Ideal).

3. Two sets of wipe off cards were used by Trend Enterprises.

   a. Design Copying, Level 2: 12 wipe off cards consist of 4 designs each with space to copy under each design.

   b. Finish the Picture, Level 2: 12 wipe off cards contain a half figure and the student was required to draw the other half.

4. Teacher-made designs were drawn on poster board (3 inches by 3 inches) and laminated. Twenty-five designs were created in increasing complexity. All students with a deficit score in constructional dyspraxia were expected to master at least 20 of these designs by the end of the therapy.

5. Two Etch-A-Sketch's were used in a number of ways to remediate reproduction of designs.

   a. The therapist would draw a part of the design and the student would copy each piece until the design was complete.

   b. The therapist would draw the entire design with the child watching and he would have to copy it.

   c. The therapist would draw the design out of the child's view and he would have to copy it on his Etch-A-Sketch.

d. The design would be drawn in view, the student would have 10 additional seconds to look at it, the design would be taken away, and then the student would produce it from memory.

6. A game called "Half and Half" was played with the student. An 8 1/2 x 11" paper was used and a vertical line was drawn dividing the paper in half. The therapist drew something that could be divided in half and would be the same on the opposite side such as a person. The therapist drew it piece by piece and the student copied after each part.

7. Activity books from drug or dime stores include drawings that have been divided into equal parts as well as an empty box that has been divided into the same equal parts. The student is expected to transfer the drawing to the empty box (see Figure 12).

Dsynomia

1. Pictures of common objects were used to remediate this deficit (Peabody Language Kit, Level 3 - American Guidance).

2. Students with this deficit were required to name a group of shapes. If there was trouble with the naming, the student was instructed to describe the design verbally and to repeat the name of the design as he copied over the outline with his finger.

3. A person, place or thing was described and the student would be required to give the appropriate name.

4. Students having this problem were encouraged to relax when they had difficulty retrieving a word and then go through a series of steps leading them to the correct name.

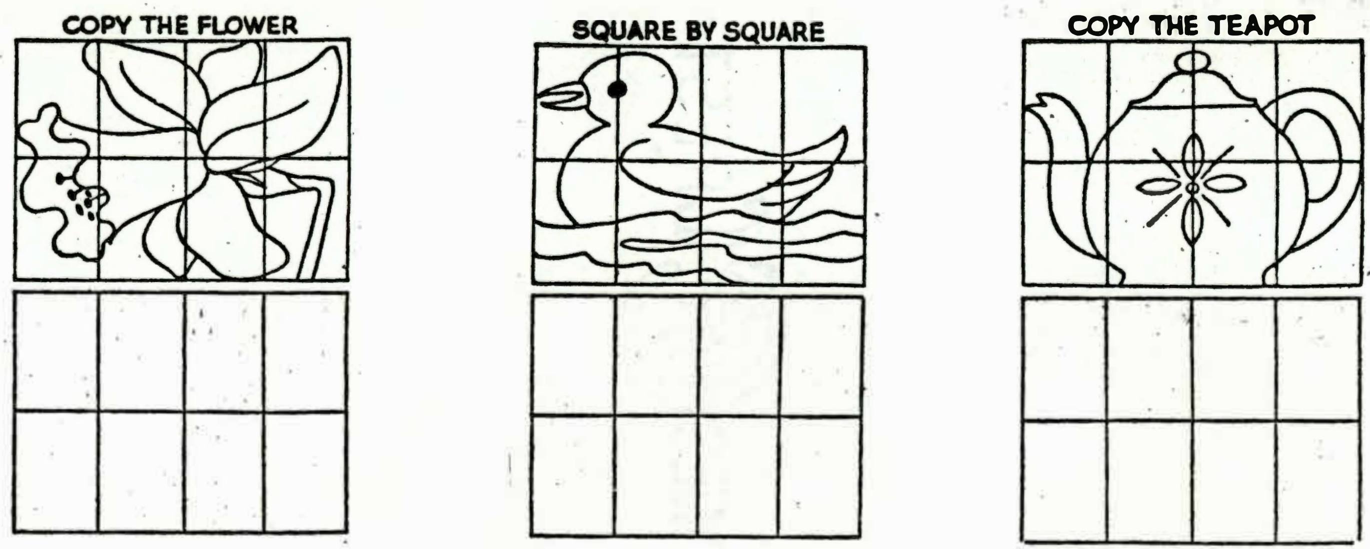


Figure 12. Examples of Constructional Dyspraxia.

Spelling Dyspraxia

The computerized game "Spelling Bee" (Texas Instruments) was used as the major basis for spelling remediation. It has three games that were pertinent. It was predetermined that no more than 10% of each session would be spent on this skill.

1. The regular Spelling game consists of a book with 264 numbered pictures in order of increasing difficulty from first to sixth grade level. When the computer is turned on, a specific level of difficulty can be determined by choosing level 1, 2, or 3. After the level is chosen a number appears on the screen. The student turns to that numbered picture and attempts to spell the word. When he has finished he pushes the ENTER button and either RIGHT or WRONG flashes on the screen. If the student is wrong the first time, he gets a second chance. If he is wrong the second time the correct spelling of the word flashes on the screen and then the next number appears. After five words have been attempted the computer displays how many have been correct by the number of stars on the screen.

2. The Mystery Word game is initiated by punching the button for that game. Then a specified number of blanks appear on the screen. It is played similar to the game of Hangman in that the student presses the letter he suspects is in the word and if it appears anywhere the computer fills that letter in the blank.

3. The Scramble game must be played by two people. One person spells a word into the computer and then punches the scramble button. The computer then completely scrambles the word and the other person attempts to figure out what the word was originally.

4. From the Spelling game five words, with which the student had difficulty, were sent home to study for homework. The following session the student was required to spell each of them orally and in writing.

<u>Dysgraphia</u>

1. The LD child often forms letters incorrectly in cursive writing. Since many of them have a large number of letters that are formed incorrectly, priorities were set by working individually on those letters that either (a) were not readily identifiable, (b) were confused with other letters, (c) took a great deal of time to execute and thus significantly slowed down the flow of writing. The letters were practiced in this order:

   a. Clay was placed in a shallow pan and the student used a wooden stylus to make the strokes.
   b. The finger traced over the letter on sandpaper.
   c. The student traced over the letter drawn as a whole.
   d. The student traced over the letter drawn as dotted lines.

2. It was required that the spelling words that were assigned for homework were to be carefully written five times each in cursive. If any were missed the next session then they were written 10 times each for homework. The examiner carefully watched the writing of each of the words at least once during the session in order to make sure that the student was not going to be practicing improper formation of letters.

3. Sentences were dictated and careful attention was paid to formation of letters.

4. The reading words that were assigned for homework were also written five times each in cursive if they were missed.

Dyslexia

Seven out of the eight subjects showed a deficit in the area of reading. It was predetermined that no more than 10% of each session would be spent on direct word recognition skills.

1. No direct reading of stories was done during the sessions. Instead, the student would take home a story from the appropriate level in the SRA kit. He was required to read the story aloud to a parent and to answer the questions at the end. The therapist would check these responses at the beginning of the next session.

2. The Dolch sight vocabulary cards (Garrard) were used at the appropriate level. The student was asked to read the words until ten words showed a significant delay or improper pronunciation. These were placed separately in a pile and the student was asked to neatly write each word on a 3 X 5 card so that they could be studied for homework.

3. Plastic cubes with various beginning sounds, blends, and word endings were used to make words (Instructo). A number of these could be rolled and words formed only using the sides that showed.

4. Turn-A-Word (Creative Playthings) is five-sided attached blocks with vowels in the center and two sets of consonants on the ends. By turning the blocks the student could form various combinations of three letter words.

5. A form of the game Concentration was constructed by the therapist in order to increase reading skills whereby a match is obtained with the picture and the word rather than two pictures matching or two words matching.

6. Magic Cards (Ideal) fit into plastic envelopes so that the student could mark with a grease pencil and it could be erased. There

were exercises for initial and final consonants, blends and diagraphs, and vowels. These were used by the students who were basically non-readers or first grade level.

7. Blend Dominoes (Ideal) were used for word recognition.

Central Dysarthria

1. The student's misarticulations were determined and no more than 5% of the session was spent on pronouncing words in this deficit area. Ten words were sent home for practice on flash cards.

2. To facilitate the identification of specific misarticulations the therapist cut out pictures exemplifying the various phonemes in the initial, medial, and final position to be used during the therapy.

3. The student was provided with frequent (unobtrusive) modeling of the sound or sounds that the child was misarticulating without calling undue attention to the error. An attempt was made to bombard the child with the appropriate model for consistent stimulation.

4. The following methods were used to practice correct articulations of the misarticulated sound:

a. The "m" sound—Have the child press a finger against one nostril and then against the other as he hums "m m m m m mee mee." Tell him to pretend he is part of a band playing simple tunes using his nose as an instrument.

b. The "k" sound—Have the child pretend he is a crow whose tongue is stuck under his bottom teeth and can only whisper "kuh, kuh, kuh." Demonstrate by placing your tongue below your front teeth and producing the sound. Tell him to pretend to fly, saying the crow whisper without getting his tongue unstuck.

c. The "p" sound—Give the student a thin strip of paper and have him hold it vertically over his mouth with a finger pressed under his nose. Have him pretend he is a motor boat, as he says, "puh, puh, puh," blowing the paper with tiny puffs of air.

d. The "g" sound—Tell the child that in a secret language "ugh ugh" means "yes" and "oog oog" means "no." Ask him simple questions and have him answer you in this new language. Tell him that the people who speak this secret language always hold their hands under their chin when they answer questions. (This provides him with a tactile cue and increased kinesthetic awareness.)

e. The "f" sound—Have the student play the "Finger Freeze" game. Tell him to wet his finger and place it crosswise on his chin. Tell him to blow "f-f-f-f" until it feels cold. Make sure the articulators are in the correct position while this exercise is being done.

f. The "v" sound—Have the student hold his fingers along the upper edge of the lower lip and "make it buzz" by prolonging the "v-v-v" (not "vee"). Show him that this produces a sound just like singing with a tissue paper over a comb. Encourage him to produce tunes with the "finger buzzing" sound.

g. The "sh" sound—Have the child role play "teacher" by pretending to quiet the class. He then puts his fingers to his lips and says "sh."

h. The "ch" sound—Have the student produce this sound by imitating a train.

i. The "j" sound—Have the student pretend to be a frog, repeating "jeojoom."

j. The "s" sound—Have the student blow up his cheeks and pretend he is a tire. "Puncture" the tire and have the child go "s-s-s-s-s" until the air is gone.

k. The "z" sound—Have the student pretend to be a bee.

l. The "l" sound—Have the student open his mouth and do exercises with both mouth and arms in coordination. As his arms swing up in an arc over his head, he lefts his tongue up to the upper gums and says, "lllll" (not "ell"). As he drops his arms he drops his tongue saying "ah," thus producing "la." Repeat with other vowels, e.g., "llllee," "llloo," etc.

m. The "r" sound—At the blackboard (or in the air) have the student make connected circles (for visual-motor integration and laterality and directionality practice the circles should be made in a counterclockwise fashion and the movement of the pattern of circles across the blackboard should be from left to right). Have him produce the circles all across the blackboard while saying "r-r-r-r-r."

n. The unvoiced "th" sound—Have him pretend to eat soup and then "cool off" his tongue by putting the front of his tongue just outside his teeth and blowing until his tongue is "cool."

o. The voiced "th" sound—Have the student make his tongue "buzz" against his fingers by holding his fingers vertically against his lips to produce the voiced "th" sound. Have him make up sounds and words by performing the prescribed action and then taking his hand away while adding a vowel, e.g., "th...ee," "th...o," etc.

Dyscalculia

It was predetermined that no more than 10% of each session would be spent on mathematical concepts. A number of areas were addressed in remediation: computation skills, fractions, measurements, time, and money.

1. The Little Professor (Texas Instruments) was used for computational remediation. It is a computer that consists of 16,000 problems that fall into four levels of difficulty. The problems appear on the screen in groups of ten and the student receives feedback for each problem (if correct a new problem flashes on the screen) as well as an indication of the number of correct answers out of ten calculations. Addition, subtraction, multiplication, and division are all included.

2. The Calculation Cubes (DLM) consist of 12 plastic cubes with each one having these six numbers on the six sides: -2, -1, +2, +3, +4, and +5. Any number up to all 12 could be rolled and the student had to determine the correct answer. They would also be rolled in twos or greater and multiplication calculation could be done.

3. The Milton Bradley flashcards in all four computational areas were used. The ones that gave the student difficulty were copied onto 3 X 5 cards and studied at home.

4. The Cuisenaire Rods (Cuisenaire Co. of America) which are described in Chapter I of this paper were used to teach regrouping in addition, subtraction, multiplication, division, and fractions.

5. For those students who still needed a very concrete illustration of basic multiplication, styrofoam egg cartons were used along with discs or coins.

6. A reusable tablet with 20 activity sheets called 1 Place Multipliers (Trend Enterprises) was used with the students.

7. A reusable tablet that could be wiped off called Beginning Division (Trend Enterprises) was used. It consisted of twenty activity sheets that had lower level division problems.

8. Addition discs, subtraction discs, multiplication discs, and division discs (Trend Enterprises) were used. The student could dial a problem, choose an answer, and turn the disc to check the answer.

9. All the treatment subjects had a great deal of difficulty with fractions. The following commercial products were used:

   a. Fraction Match Ups - Pie Forms (DLM).

   b. Dig Into Fractions (Milton Bradley).

   c. Fraction Discs (Milton Bradley).

   d. Fit-a-Fraction - Circles (Lauri).

   e. Fit-a-Fraction - Squares (Lauri).

10. Liquid and dry measurements were presented using Measurement by Instructo.

11. Linear measurement of inches, feet and yards were presented by Measurement Treasure Hunts (Instructo) and Measuring (Milton Bradley).

12. The measurement section lessons from the appropriate level SRA kit were used for homework.

13. Money, Level 3 (Trend Enterprises) provided 12 wipe off cards that presented sets of coins to be totaled.

14. Telling Time, Level 2 and 3 (Trend Enterprises) provided wipe off cards dealing with time on the hour, half-hour, quarter-hour, and five minute intervals.

15. A conception of counting seconds was obtained through use of the therapist's stop watch. At a certain time the watch was stopped and the student had to say how many seconds had passed. He could check his accuracy by learning to read the stop watch.

Right-Left Confusion

1. For those students having difficulty in this area, lists of activities were devised and placed in groups of tens. One of the sample sets is listed below:

a. Put your left hand on your head.

b. Put your right hand on your left knee.

c. Shake your left foot.

d. Put your right foot behind your left knee.

e. Touch your left eye with your left hand.

f. Put your chin on your right shoulder.

g. Put your left fingers on your right ear.

h. Put your right elbow on your left knee.

i. Put your left foot on your right knee.

j. Touch your right toes with your left hand.

2. Concept Record #3 (Children's Music Center) was used for remediation in this area. It is a long-play record designed to develop body orientation through active participation. It assists in gross and fine muscle development, left-right, and up-down.

3. Specific cues were devised by the student and the therapist together so that he could help himself more quickly orient to right versus left. The cues were individualized based on the student's perception of what would be helpful. The most popular cue is that of determining which hand you write with and then saying, "That's my right hand," as long as the dominant hand is right. Other children have identifying marks on one hand or the other such as a large mole or freckle and they then use that for identification.

4. After the student was consistently responding to right-left regarding his own body, he was then asked to point out the therapist's body parts while facing her. Pictures of people were also used for this right-left discrimination.

5. Body-Image Laterality (Ideal) is a set of twenty-two sheets designed to provide practice in laterality, directionality, spatial relations, and right-left orientation. They were used for homework for those showing a deficit in right-left confusion.

Auditory Verbal Dysgnosia

1. A student having a deficit in this area was asked to explain five sentences each session. Twenty examples are as follows:

a. The rabbit scrambled around in the garden.

b. I saw a marvelous coat in the store.

c. What a tremendous sight!

d. The man felt depressed when he heard the news.

e. Life is strange at times.

f. My sister is jealous of me.

g. I thought that was outrageous.

h. All of my family descended upon me.

i. I was scared to knock on the door.

j. He was reluctant to tell me the news.

k. Time flies when you're having fun.

l. Those days are gone forever.

m. He is very brave.

n. Only you can prevent forest fires.

o. I wrote a revealing letter to my secret pal.

p. John was delighted with the present.

q. My daughter has brought me much joy.

r. That picture you made for me is priceless.

s. Let me hasten to tell you that I cannot be there.

t. What in the world is going on?

2. The therapist presented idiomatic expressions and encouraged discussion regarding possible meanings, e.g., "has a green thumb," "hopping mad," "clear the air," etc. The student was asked to talk to his parents and bring in other examples.

3. For those students who were ready for more abstract levels of verbal expression, proverbs were presented. Some examples are "The longest journey begins with the first step," and "A bird in the hand is worth two in the bush." The therapist encouraged the student to make adequate generalizations as well as talking to family members or other adults and bringing their own proverb to the next session.

Visual Number Dysgnosia

1. In those children who were close to being nonreaders and for those who confused some of the number words, flash cards were made

with the number words one to twenty. The student studied at home those he had difficulty reading in the session.

2. Groups of lists were made similar to the task that was asked on the test (7 - SIX - 2). See Figure 13 for an example of one list. There were a total of twenty different lists.

Visual Letter Dysgnosia

On the test the student is asked to name three letters in a group. The letters with which the student had trouble were determined by having him read Alphabet Cards (Charles E. Merrill). The missed letters were then interspersed with acquired letters and the student was asked to read these in lists of ten each. An example list from one student who had trouble with U, V, Y, W, M, and N is listed below:

BUR
VOX
DAW
PMQ
NRT
CZU
WIF
GVH
JXY
YEK

Other commercial products used for letter identification are as follows:

a. Alphabet Cards (DLM)

b. Letto (Houghton Mifflin)

5	TWO	8
4	THREE	7
8	NINE	5
3	FIVE	4
9	SEVEN	2
7	FOUR	3
6	EIGHT	2
9	ONE	6
8	TEN	4
2	FOUR	8
3	FIVE	5
7	ONE	9
6	TWO	3

Figure 13. Examples of Visual Number Dysgnosia.

Body Dysgnosia

1. The same lists that were used for right-left confusion were also used to remediate students who confused body parts.

2. Basic concepts through Dance Album Series (Educational Activities, Inc.). Parts of these two records were used for development of body image and position in space.

Vocabulary

1. The student was asked to define words using at least two descriptive categories.

2. Each subject was given five words a session to define and use in a sentence.

3. The student was asked to identify an object after listening to a description of color, shape, size, texture, etc.

4. He was asked to describe various objects according to size, color, shape, materials made from, what can be done with them, who might use them, and other characteristics (e.g., hard-soft, long-short, "I spy something that is . . . ," etc.).

5. The student was asked to assume the identity of a piece of furniture, a fruit, an animal, etc. He had to answer questions posed by the therapist such as "do you eat?" "do you have fun?" or "are you soft?" Such a technique forced the child to focus attention upon the relevant and irrelevant descriptive features and provided the therapist with the opportunity to observe dissociative thinking or misunderstandings.

6. The student was asked to finish sentences by the therapist, describing something, e.g., "A horse . . ." (is big, has four legs, has

a tail, can be ridden) or stating actions, e.g., "A horse . . . (runs, gallops, canters, trots, walks).

7. A football field gameboard was created in order to add interest to the activity of defining words. The student would start down at his goal line and would have to go 100 yards to win. He would be asked to define a word. If he did not know it at all he would stay at the same place and the definition would be discussed with him. If he gave a correct answer but vague or concrete (comparable to one point answers on the WISC-R) he could advance 5 yards. The therapist would provide other descriptors that would have made it a more complete definition. If it was a two-point answer he would advance 10 yards and get a "first down."

8. The word game "How many Ways?" was played. The therapist would encourage the student to use descriptive words by asking such questions as "How many ways can we say 'good'?" (wonderful, great, o.k., super, favorable, magnificent, outstanding, etc.).

9. The student and therapist would play the educational game Password (Milton Bradley).

10. An old junior level Webster dictionary was cut up separating words from their definitions and the student had to correctly match a group of ten definitions and words. The ones missed were studied for homework.

11. The student was asked to work crossword puzzles for homework. Commercial materials used were Crossword Puzzles (Ideal) and Crosswords for Reading (Educational Insights). Each student had a book that belonged only to him. He was allowed to get help from his parents at home.

Comprehension

1. The student was asked various comprehension questions and he was asked to explain his answer as well as the thinking processes he went through to get that answer. Example questions are as follows:

   a. What states are warmest in the winter?

   b. About how tall are first grade children?

   c. What does the heart do?

   d. If you were lost in the woods, how would you find your way out?

   e. If you were in a strange country where no one speaks English, what would you do to get back home?

2. The therapist asked the student to discuss personal responsibilities in various situations.

3. The necessity for rules in various games and sports were discussed.

4. The student was asked to tell the appropriate response in various emergency situations such as fire, car accident, choking, etc.

5. Reasons for having firemen, doctors, dentists, nurses, lawyers, plumbers, porters, etc. were discussed.

6. Children having a deficit in comprehension took home each session a Xerox copy of one of Aesop's Fables. They were to discuss it with their parents and then tell the therapist the meaning of the fable.

7. The need for laws and rules in daily living were discussed.

8. The student was asked to identify an advertising message and relate it to the appropriate picture. Printed ads from magazines and newspapers were used.

9. The Reading Comprehension wipe clean cards by Taskmaster were used at the following levels, 2-1, 2-2, 3-1, 3-2, 4-1, 4-2 (Taskmaster, Inc.).

10. Cause-and-effect relationships were discussed using <u>Aids to Psycholinguistic Teaching: Auditory Association</u> (Charles E. Merrill).

11. The student was asked to identify and explain verbal and pictorial absurdities using <u>Silly Sentences</u> (Houghton Mifflin) and <u>What's Wrong Here</u> (Teaching Resources).

12. The student was instructed to discuss appropriate behavior during various activities and in various situations. Teacher laminated pictures from magazines were used for discussion. Commercial products are available such as <u>Alternative Cards, Reaction Cards,</u> and <u>Written Language Cards</u> by DLM.

<u>Similarities</u>

1. Each student completed statements requiring opposites (e.g., babies are little; mothers are _____). Examples are found in <u>Aids to Psycholinguistic Teaching: Auditory Association</u> (Charles E. Merrill).

2. The student sorted and matched faces according to like moods from a group of six or more pictures displaying various facial expressions.

3. While blindfolded the child was asked to identify likenesses and differences of the tastes of various foods exhibiting sweet, sour, salty, bland, hot, cold, etc.

4. The student matched pictures that had opposite meanings.

5. The therapist made cards with some designs that were exactly alike and some slightly different. These types of tasks are also found in activity books from the drug store. The student was asked to identify likenesses and differences and to explain each.

6. Abstract ideals such as liberty, justice, honor, etc. were discussed.

7. Physical properties of simple chemical compounds were discussed.

8. Similarities and differences among letters of the alphabet were discussed.

9. Pictures of objects which have an identical use (e.g., saw-scissors, vacuum-broom) were grouped by the student.

10. The student classified objects or pictures according to broad categories (e.g., transportation, food, shelter, etc.).

11. The student was instructed to describe differences within a single category such as cats by looking at pictures (e.g., size, color, type, etc.).

12. Using Association Picture Cards III & IV (DLM), each card has three items on it that are alike in some respect and one that is different. The student was asked to verbalize the similarity and difference.

13. The following sorting and classifying wipe off cards (Trend Enterprises) were used:

   a. <u>Associations</u> - match objects to associated objects in rows of items.

   b. <u>Categorizing</u> - match cards that contain a common category of items with unrelated objects interspersed.

c. Thinking Skills - match associated objects and same category objects.

Arithmetic

This subtest on the WISC-R mainly requires that the student be able to compute arithmetic problems in his head. Practice in this skill was provided by using word problems from various math textbooks on the appropriate level for the student. The student was asked five problems in the session and he would take home five to ten problems Xeroxed from the book. The parent was asked to read the problem aloud and time the child on his response. The word problems involved the four computational areas as well as money and measurement.

Digit Span

1. The child was asked to repeat unrelated words starting from groups of 3 on up to 8.

2. The student was expected to orally repeat sentences of varying lengths.

3. He was required to retell a simple story in correct sequence.

4. The student was asked to identify missing alphabet letters or numbers in a series presented orally by the therapist, e.g., 123 - 56, FG - IJ, etc.

5. Exercises were offered when the student had to retain a statement for a specified length of time and then repeat the statement.

6. A specific word in a list of words after hearing it pronounced was recognized and identified by the student.

7. Combinations of numbers, sounds and letters were formed in lists of ten for auditory memory exercises.

8. The student was asked to repeat a mixed series of numbers and words in reverse order, e.g., 2V5R.

9. The student learned to relate the months of the year in correct sequence.

10. He related the days of the week in correct sequence.

11. The student was required to memorize a poem starting with very simplistic ones and progressing at the individual's own pace.

12. It was expected that the student would repeat a joke told to him the previous session or possibly one from many sessions removed. The joke would be identified by one key word such as "The joke about the farmer."

13. He was asked to repeat tongue twisters.

14. The child was asked to turn his back to the therapist who would bounce a ball a specific number of times and ask him to tell how many times it bounced.

15. Activities that are similar to the Oral Directions subtest of the Detroit Test of Learning Abilities were made using pages from miscellaneous workbooks and devising 2 stage-6 stage commands to go along with the rows of pictures. These pages were mounted and laminated for prolonged usage.

16. Milliken's book with 24 sets of directions, one cassette, and a teacher's guide called Auditory Memory for Directions was used with students deficient in following directions.

17. The teacher would clap a pattern out on her leg or the desk and the student had to copy the pattern by clapping. As Cruickshank suggests, the students were also asked to represent the claps in written

form by making circles to represent the clap and leaving a space to represent a pause. An example would be as follows: 00 000 0.

18. The game "I am going on a trip and I am going to take . . ." was played with the therapist. The subject had to remember the list in correct sequence and then add to the list.

19. The therapist cut out pictures of food from magazines, laminated the pictures, and made a restaurant menu including only the foods in the pictures. The pictures were stacked on a table in the room. Then the student took a food order from the therapist, pretending he was a waiter and pretending to write it on a pad. The student then went over to the stack of pictures and brought back the food that was ordered. To increase the difficulty the therapist would order as two or more people so that not only what is ordered must be remembered but also who ordered what.

Information

1. In the session we had a general discussion on one calendar month per week regarding number of days, holidays, season, etc.

2. Students deficit in this area practiced naming the months of the year in order. When that was mastered he was asked for the month coming after or before each month.

3. The child was asked to list all the holidays he could think of. The purpose behind each one was explored and discussed.

4. The student was directed to go through magazines pointing out pictures that represent the various seasons of the year. He had to explain why he believed it was a certain season in the picture.

15. The Fast Facts and Zingers by Parker Brothers were used. Each consists of 500 questions and answers on a scroll whereby the questions appear one at a time. They are general information type questions.

Picture Completion

1. Activity books from drug and dime stores often include pages with pictures having a part missing. Twenty-five of these were cut out, mounted and laminated. See Figure 14 for examples.

2. Using objects and figures from magazines, the pictures were cut in half (vertical cut) and one half was pasted on white construction paper and laminated. The student was asked to draw the missing half, paying close attention to details so that no parts would be omitted.

3. Pictures of objects were cut from magazines and catalogues. Then they were cut into several pieces (4-10) and pasted randomly on a page. The student would then have to guess the identity of the picture.

4. The student was asked to describe in detail an object, person, or picture. The purpose was to help him tune in on all the essential parts of the item being described.

5. Groups of five sentences were constructed by the therapist, each having a missing word. The student was required to identify the missing word.

6. The Fun and Do Pack by Highlights Magazine has hidden objects in pictures. These along with similar activities in other books were mounted, laminated, and used in remediation sessions.

7. The student was required to locate individual states in a map of the USA using United States Map Puzzle (Playskool).

Figure 14. Examples for Picture Completion.

5. Selected pictures cut from magazines were discussed. Each of these related to the area of general information and most were obtained from science and historical magazines.

6. The Trend Enterprises product, Animals and Their Young, was used to match animals as to full grown and babies. The student was required to write down the names of both, e.g., kitten and cat.

7. The parts of the body and their vital function were discussed.

8. A map was drawn by the student showing the way from school to home. Effort was made to orient the map in reference to the four directions.

9. The names and locations of neighboring communities were discussed and within their context the student was able to orient himself in regard to north, south, east and west.

10. Location of specific places on maps and/or globes were presented and discussed.

11. Using the State map the student was instructed to list the cites one might pass through when traveling from the home city to other cities in the state.

12. The historical perspective in relation to the major presidents was discussed from George Washington to Carter.

13. Eight wipe off crossword puzzles by Ideal were used to familiarize the student with 8 famous American people: Davy Crockett, Lincoln, Edison, Paul Revere, Ben Franklin, Washington, Frederick Douglas, and Columbus.

14. "I Spy" and "Twenty Questions" were used to apply the recognition of objects by understanding clues and descriptions.

8. The following commercial products were used:

   a. What's Missing Zoo (Instructo).

   b. Cognitive-Skills - What's Missing (Teaching Resources).

   c. Story-Cards - Tell What Part is Missing (Milton Bradley).

   d. What's Missing (Trend Enterprises).

Picture Arrangement

1. Sequence stories were made from the Sunday cartoon section of the newspaper or the daily cartoon section. Preferred cartoons were those that rely on observation of the viewed actions rather than on words. The therapist marked through any words so that the student had to visually analyze what he saw. Cartoons chosen were pasted onto cardboard, covered with clear contact paper, then cut into their individual frames. The frames had to provide sufficient clues to their sequencing for the cartoon to be of value in this activity. The cartoon strips were 3-12 frames in length (See Figure 15.)

2. The student was asked to list in order what he did on the weekend starting from Friday after school until Sunday night. There had to be not less than 10 items. If the written language skills were too low, then this was sequenced orally.

3. The student was required to arrange in correct sequence directions for a specific task which had been individually written on several pieces of paper.

4. Teacher-made activities of scrambled sentences in groups of five were used.

5. Students arranged individual words in correct order to produce specific sentences (teacher-made words on cards).

a) Cat and Dog

b) Dagwood

c) Porcupine

Figure 15. Examples of Picture Arrangement.

6. The student was asked to retell a story that had been read aloud by drawing simple pictures in proper sequence.

7. The following commercials were used for remediation of picture arrangement:

a. Self-Care Sequential Cards (DLM) (6 cards in a sequence).
b. Sequential Cards - Health and Safety (DLM).
c. Consumer Sequential Cards (DLM) (6 cards in a sequence).
d. Independent-Living Sequential Cards (DLM) (6 cards in a sequence).
e. Sequential Picture Cards III and IV (DLM) (6 cards).
f. Eight Scene Sequence Cards (Milton Bradley).
g. Twelve Scene Sequence Cards (Milton Bradley).

Block Design

1. Using the 25 wood 2" Color Cubes (Playskool), the students reproduced designs created by the therapist. The cubes have combinations of red, white, blue, and yellow, similar to the old Wechsler blocks. Patterns were made only with yellow and blue so that the activity would not be direct practice of the red and white patterns on the WISC-R. See Figure 16 for examples of the designs.

2. The student was asked to reproduce teacher-made forms with match sticks.

3. Teacher-made dominoes which require the matching of block design patterns were used.

4. The student was asked to identify the hidden object in figure-ground exercises. Books containing these can be easily found in bookstores, toy stores, department stores, and grocery stores.

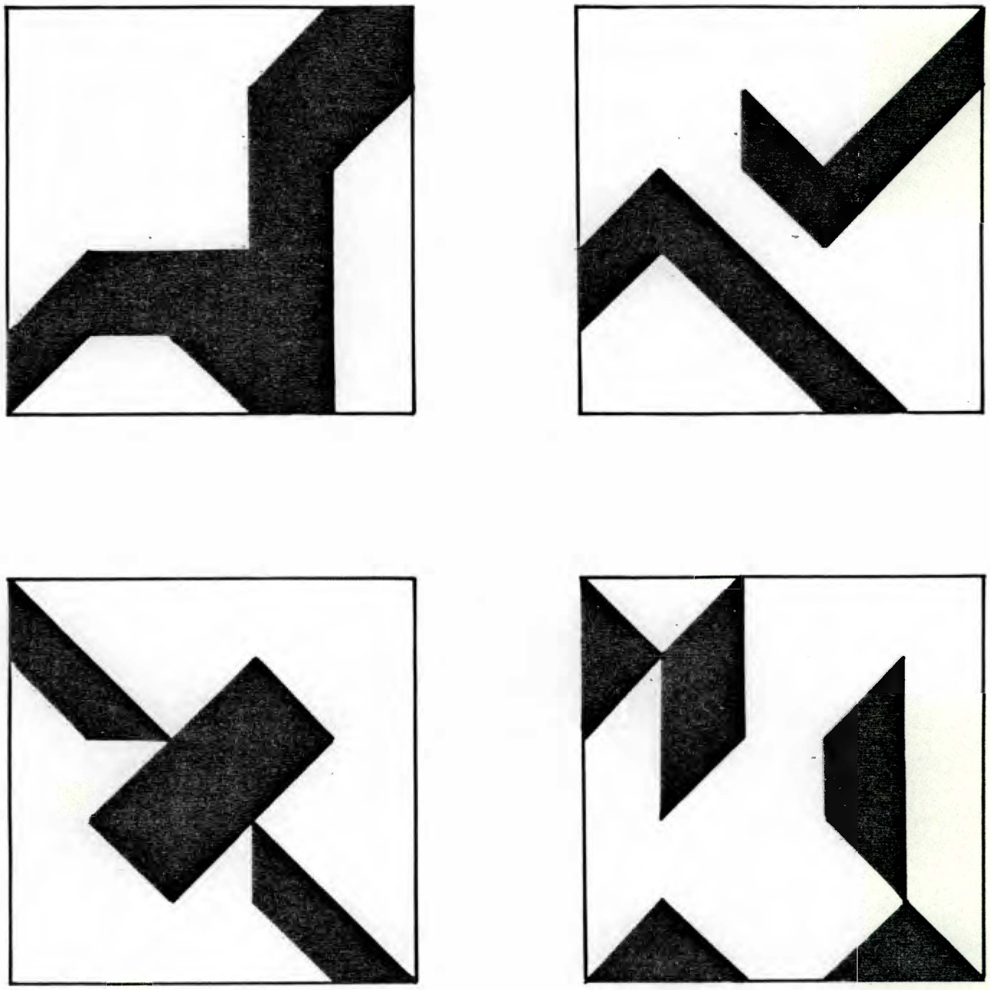


Figure 16. Examples of Block Design.

5. The student was asked to select from a box of tactile materials the appropriate pieces and reproduce a design presented on a card using Block Design - Kelp (Webster).

6. The child could reproduce designs using triangles, hexangles, and quadrilaterals. The following commercial products were used (Kohner Brothers, Inc.):

a. Pythagoras

b. Hexed

c. Kwazy Quilt

d. Hi-Jinks

e. Voodoo

f. Sweetheart

7. The following commercially produced puzzles and design patterns were used:

a. Playtiles and Playtile Pattern Cards (Playskool). Playtiles are plastic pieces in 3 shapes and 4 colors that snap into a plastic pegboard. The set consists of 214 pieces and there are 18 pattern cards. Designs progress from two color geometric patterns to four color pictures of real objects. Teacher-made patterns were also used.

b. Reproduce designs using pegboards and pegs (DLM).

c. Parquetry Block Designs and Parquetry Blocks (DLM).

d. One-inch cubes were used with cube designs in perspective (DLM).

e. Kaleidoscope Puzzles (Ideal) consist of 12 colorful design patterns that can be replicated by using 4 patterns to make the design.

f. Soma Puzzle Game (Parker Brothers).

g. Create-A-Cubes (Varis).

Object Assembly

1. The therapist made puzzles from pictures that were mounted on posterboard and laminated. There were five dimensions upon which these puzzles varied. First, the picture ranged from very simple pictures such as a cat to very complex pictures involving numerous stimuli. Second, they were as large as 8 1/2" X 11" and as small as a bubblegum card. Third, some of the pictures were in square or rectangular form and others were made by cutting along the outside of the design such as the shape of a house, car, person, etc. Fourth, the number of pieces cut varied from 2 to 20 pieces. Last, some pictures were cut into even pieces so that each piece was the same shape and others were cut into all different size pieces. The pieces for each puzzle were stored in an individual envelope.

2. The following commercially produced puzzles were also used:

a. Wooden puzzles by Playskool (15-21 pieces).

b. Jigsaw Puzzles (25 to 100 pieces).

c. Throughout the 4 months there was a large jigsaw puzzle (200 pieces) continuously left on the table that was worked by those students who were slightly deficient in object assembly (subtests scores 7+) as a part of their curriculum and for a few minutes after each therapy by those who did well on object assembly and who worked on the puzzle as a reward for completing the session.

d. Puzzles by Teaching Resource Corporation.

e. Animal Puzzles (DLM).

3. The therapist put together word cards cut in two or more pieces using the spelling words to be studied for homework.

4. The student was asked to identify pictures of objects when a portion of the picture was hidden.

5. The student assembled a puzzle of the United States (Playskool).

6. The student was asked to reproduce a design made of building toys from a model made by the therapist ahead of time. This was timed to increase the level of difficulty. Bristle Blocks (Playskool), Lincoln Logs (Playskool) and Tinkertoys were used.

7. The student and therapist played Qubic, which is 3-D tic-tac-toe (Parker Brothers).

Mazes

1. There are a number of commercially produced activity books that are readily available in supermarkets, drug stores, dime stores, and toy stores. The mazes in these were Xeroxed and used with those children deficient in this area.

2. Activity books also include word-hunt games that were used. There the student was asked to circle the hidden words.

3. The student was asked to draw lines in correct sequence between appropriate letters in a maze to spell a specific word using teacher-made materials. Words used depended upon the spelling level of the student and were typically ones that had been studied for spelling words for homework between sessions.

4. On some of the maze activities, the student was asked to complete them while verbalizing the directions taken to solve the maze.

5. The student was required to describe verbally how to get home from school or how to go from home to a friend's house using landmarks (e.g., stores, churches, gas stations, etc.). The student also learned to verbalize directions from his house to the office where the remediation sessions were held.

6. The student traced the highways on a map for traveling from his hometown to another city.

Coding

1. Using sets of pictures, a series of pictures were placed in a specific order in front of the student. The number of cards used was 3 or more depending upon the level of the individual. The pictures were picked up and shuffled and then the student attempted to place them in the identical order. The difficulty of this task was increased not only by displaying a greater number of cards but also by putting them back into a deck of pictures where the student had to then identify the pictures from a large set as well as remembering the order. The pictures were teacher-made or they came from commercial educational games made for younger students.

2. The student viewed a group of objects on a tray. When they were removed the task was to remember as many of those objects as possible. The answer could either be in oral or written form.

3. The student viewed a group of objects on a tray. The teacher removed one or two objects and the child had to name the missing item or items.

4. The student reproduced a pattern on the xylophone starting from a sequence of 3 notes up to the number that could be produced correctly 75% of the time.

5. The student completed simple anagrams using a number-letter or geometric form-letter code system in a specified period of time using teacher-made anagrams.

6. The student was required to match Roman numerals to Arabic numbers in a specified length of time using teacher-made Roman numeral flashcards.

7. The student reproduced a design drawn on paper and displayed to the student for 10 seconds by using an Etch-A-Sketch (Creative Playthings).

8. The therapist showed the student various teacher-made flashcards of shapes, words, numbers and short sentences. These were similar to those in the Slingerland Screening Tests for Children with Learning Disabilities. Each was shown from 10 to 20 seconds and was reproduced on paper from memory.

9. The therapist made up coding patterns similar to those on the WISC-R but not using the same order of numbers or any of the same designs. For this study 20 different design patterns were made. The students were allowed to go all the way to the end rather than stopping at 2 minutes and progress was noted by a decrease in the total time needed to finishing the coding patterns.

10. The Target Test from the Reitan-Indiana Neuropsychological Battery for Children was used as training for visual memory. The dotted patterns are pictured in Figure 17. Twelve different patterns were created by the therapist and one such pattern is shown in Figure 18.

11. Two commercial games by Milton Bradley were used:

a. Concentration

b. Memory: Card Matching Game

TARGET SHEET

Name: ______________________ **Date:** ________ **Examiner:** _____ **Score:** _____

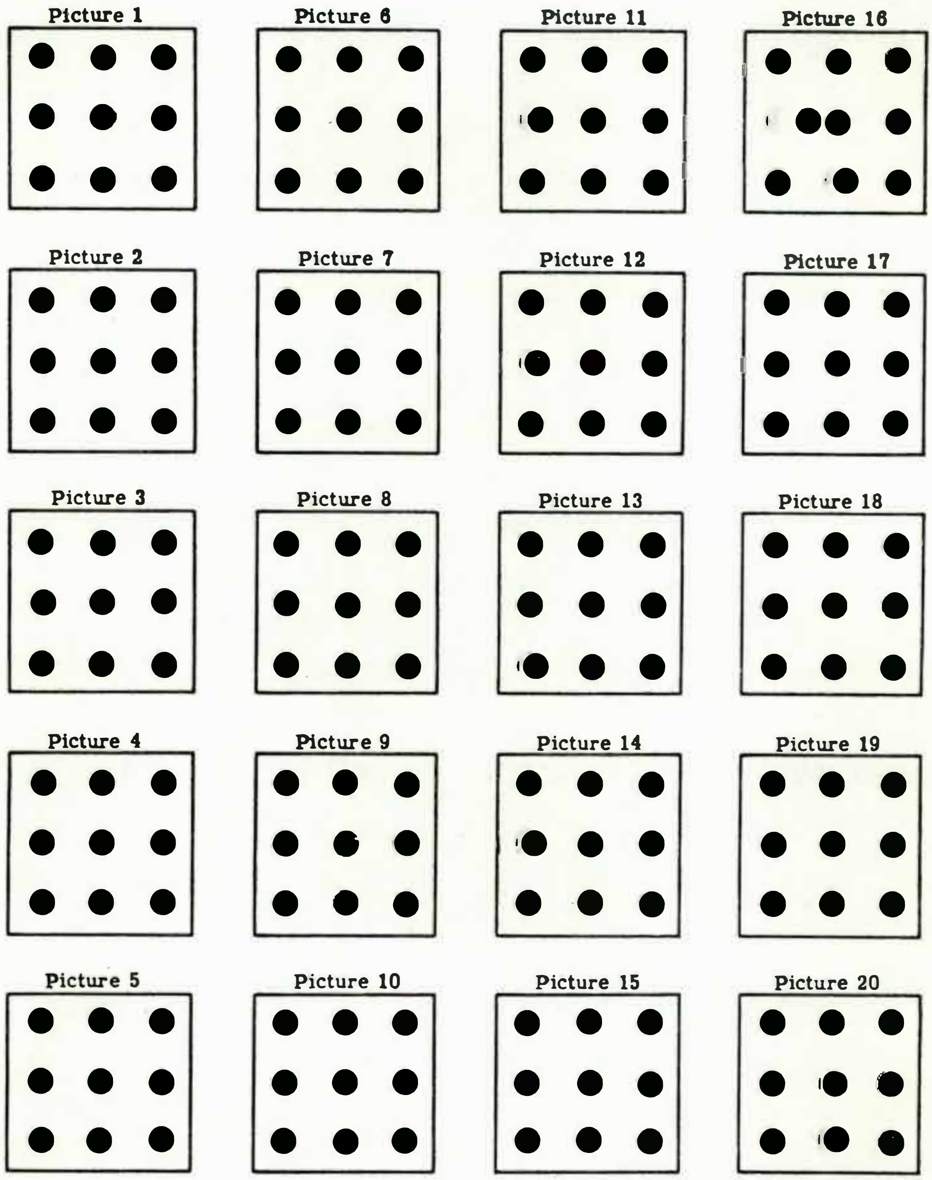


Figure 17. Target Test.

TARGET SHEET

Name: ______________________ **Date:** ________ **Examiner:** _____ **Score:** _____

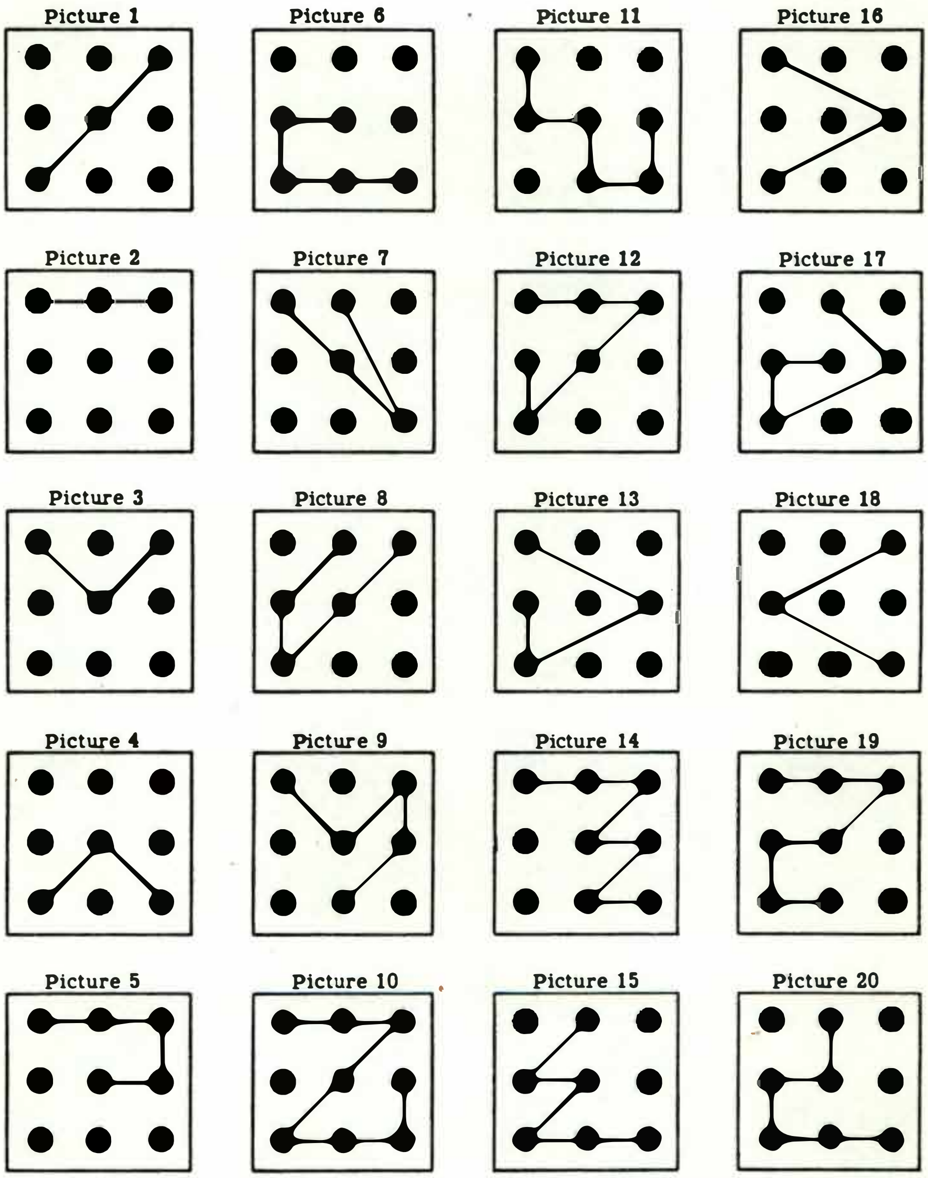


Figure 18. Example of Therapist Created Patterns for Target Test.

12. Concentration was played with a regular deck of cards.

13. The Visual Memory Cards: Sets III and IV (DLM) were used to provide training in visual discrimination, sequencing and memory. Set III deals with complex shapes and IV with letters. Each set contains 60 cards.

14. The students all had their own copy of Mickey Mouse's Secret Code 'n Things (Whitman). These were assigned for homework.

15. Each student learned to use a map legend by having him find roads, rivers, mountains, cities, etc.

List of Publishers

American Guidance Service, Inc.
Publisher's Building
Circle Pines, Minnesota 55014

Charles E. Merrill Publishing Company
(Division of Bell & Howell)
1300 Alum Creek Drive
Columbus, Ohio 43216

Children's Music Center, Inc.
5373 West Pico Boulevard
Los Angeles, California 90019

Creative Playthings
Edinburg Road
Cranbury, New Jersey 08540

Cuisenaire Company of America
9 Elm Avenue
Mt. Vernon, New York 10550

Developmental Learning Materials (DLM)
7440 Natchez Avenue
Niles, Illinois 60640

Education Insights
211 South Hindry Avenue
Inglewood, California 90301

Educational Activities, Inc.
Box 392
Freeport, New York 11520

Garrard Publishing Company
Champaign, Illinois

Highlights for Children
2300 West Fifth Avenue
Columbus, Ohio 43216

Houghton Mifflin Company
53 West 43rd Street
New York, New York 10036

Ideal School Supply
11000 South Lavergne Avenue
Oak Lawn, Illinois 60453

Instructo Corporation
(Division of McGraw-Hill)
200 Cedar Hollow Road
Paoli, Pennsylvania 19301

Kohner Brothers, Inc.
(Tryne Game Division)
P.O. Box 294
East Paterson, New Jersey 07407

Lauri Enterprises
Phillips-Avon, Maine 04966

Learning Concepts
2501 North Lamar
Austin, Texas 78705

Milliken Publishing Company
611 Olive Street
St. Louis, Missouri 63101

Milton Bradley
74 Park Street
Springfield, Massachusetts 01105

Parker Brothers
200 Fifth Avenue
Suite 634
New York, New York 10010

Playskool
(Division of Milton Bradley)
Springfield, Massachusetts 01101

Science Research Associates (SRA)
(Subsidiary of IBM)
155 North Wacker Drive
Chicago, Illinois 60606

Smethport Specialty Company
Smithport, Pennsylvania 16749

Teaching Resources Corporation
100 Boylston Street
Boston, Massachusetts 02116

Texas Instruments, Inc.
P.O. Box 225012, MS 54
Dallas, Texas 75265

Trend Enterprises
P.O. Box 3073
St. Paul, Minnesota 55165

Varis Associates
P.O. Box 893
Hicksville, New York 11802

Webster Publishing Company
(Division of McGraw-Hill)
Manchester Road
Manchester, Missouri 63011

Whitman Books
Western Publishing Company
Racine, Wisconsin

CHAPTER III

RESULTS

Neuropsychological Data

Wechsler Intelligence Scale for Children—Revised (WISC-R)

Table 4 shows the average intelligence quotients (Verbal, Performance, and Full Scale) for the three groups of students. As can be seen in Table 4, all three groups showed an average gain in the three IQ scores. Tukey's Wholly Significant Difference (WSD) test was the method of multiple comparison used to evaluate the magnitude of difference between pairs of means of the subtests.

Table 4

Mean IQ Levels on the WISC-R for Treatment, LD Control, and Normal Control Students

	Pretest	Posttest
	Treatment (n=8)	
Verbal IQ	93.75	99.50
Performance IQ	100.13	112.38
Full Scale IQ	96.25	105.88
	LD Control (n=5)	
Verbal IQ	90.80	96.00
Performance IQ	100.60	112.80
Full Scale IQ	95.00	103.80
	Normal Control (n-10)	
Verbal IQ	117.80	119.10
Performance IQ	114.50	120.20
Full Scale IQ	118.10	122.20

Table 5 shows the mean change score differences among the three student groups for the Verbal, Performance, and Full Scale IQ. Using the .05 level of significance (.05 q 3, 20 = 3.58), and the appropriate n" to compare one group against the other (N" = 6.15 to compare Treatment versus LD Control, N" = 8.89 to compare Treatment versus Normal Control, and N" = 6.67 to compare LD Control versus Normal Control), none of the pairwise comparisons reached significance.

Table 5

Mean Change IQ Score Differences for Treatment, LD Control, and Normal Control Students

	Treatment (n=8)	LD Control (n=5)	Normal Control (n=10)
		Verbal IQ	
$\overline{X}$	5.75	5.20	1.30
S	5.28	7.40	6.58
		Performance IQ	
$\overline{X}$	12.25	12.20	5.70
S	8.92	10.55	7.51
		Full Scale IQ	
$\overline{X}$	9.63	8.80	4.10
S	7.82	8.11	6.05

Table 6 presents the mean pre and post subtest scores from the WISC-R for all three groups. It can be noted that all subtest scores except for Digit Span and Mazes increased for the Treatment and Normal Control groups and all subtest scores except for Similarities and Comprehension increased for the LD Control group. Table 7 shows the mean change score differences for all subtests. It can be noted that for eight out of the twelve subtests (Information, Similarities, Arithmetic,

Table 6

Mean Pre and Post Subtest Scores for the Treatment, LD Control, and Normal Control Groups

	Treatment		LD Control		Normal Control	
	Pre	Post	Pre	Post	Pre	Post
Information	8.13	10.50	8.40	9.60	13.7	14.1
Similarities	10.13	11.13	9.60	9.20[a]	13.7	13.8
Arithmetic	6.75	8.00	6.80	8.00	11.0	11.2
Comprehension	11.13	12.00	12.00	10.04[a]	14.30	14.50
Vocabulary	10.75	11.00	7.00	9.00	13.90	14.30
Digit Span	7.25	7.13[a]	8.60	10.00	10.90	11.80[a]
Picture Completion	10.75	12.13	12.00	12.40	13.10	13.60
Picture Arrangement	10.75	14.13	11.00	14.20	12.40	13.40
Block Design	8.75	11.75	11.60	12.40	12.10	12.30
Object Assembly	11.13	10.75	9.80	12.80	12.00	13.40
Coding	7.00	11.13	6.60	9.60	12.00	12.20
Mazes	12.00	11.00[a]	10.00	10.00[a]	11.10	12.70

[a]Mean subtest scores decrease.

Table 7

Mean Change WISC-R Subtest Score Differences for the Treatment, LD Control, and Normal Control Students

	Treatment (n=8)		LD Control (n=5)		Normal Control (n=10)	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
Information	2.38	2.20	1.20	1.30	.40	2.07
Similarities	1.00	2.20	-.40	2.51	.10	2.47
Arithmetic	1.25	1.28	1.20	1.30	.20	2.90
Comprehension	.88	3.36	-1.60	2.70	.20	2.04
Vocabulary	.25	1.39	2.00	.71	.40	1.71
Digit Span	-.13	3.14	1.40	3.58	.90	2.13
Picture Completion	1.38	2.26	.40	3.05	.50	1.78
Picture Arrangement	3.38	1.92	3.20	3.70	1.00	2.49
Block Design	3.00	3.70	.80	1.30	.20	2.53
Object Assembly	-.38	2.07	3.00	3.87	1.40	3.66
Coding	4.13*	3.18	3.00	3.74	.20*	1.32
Mazes	-1.00	2.33	.00	2.45	1.60	2.37

*Pairwise comparison was significant at the .05 level.

Comprehension, Picture Completion, Picture Arrangement, Block Design, and Coding) the Treatment group showed a larger mean change score than either the LD Control group or the Normal Control group. However, using Tukey's WSD, only one of these pairwise comparisons reached statistical significance. The mean change score of the Coding subtest for the Treatment group was significantly greater than the Normal Control group although the difference between the Treatment group and the LD Control group did not reach significance at the .05 level.

Selz and Reitan Score

Table 8 shows the mean pre and post Selz and Reitan scores for all three groups. These scores represent an overall degree of neuropsychological impairment with 0-19 classified as normal, 20-35 classified as learning disabled, and above 36 classified as damaged. It can be noted that the Treatment group showed a larger degree of improvement on posttesting than the LD Control and that the LD Control showed a greater degree of improvement than the Normal Control group. The mean change score differences are presented in Table 9. Using Tukey's WSD, the only pairwise comparison that reached statistical significance at the .05 level was the difference between the Treatment group and the Normal Control group.

Halstead-Reitan Neuropsychological Battery

The Selz and Reitan score consists of the 37 variables that appear in Table 1 (page 18). Eight of these were chosen to be analyzed separately. The Category Test, Tactual Performance Test Total Time, Tactual Performance Test Memory, Tactual Performance Test Localization,

Table 8

Mean Selz and Reitan Scores for Treatment, LD Control, and Normal Control Students

	Treatment (n=8)	LD Control (n=5)	Normal Control (n=10)
Pretest	34.75	31.00	11.3
Posttest	22.13	23.20	10.1

Table 9

Tukey Pairwise Test for Mean Change Score Differences in the Selz and Reitan Score

	Treatment	LD Control	Normal Control	
$\bar{x}$	-12.63	-7.80	- 1.4	
s	4.47	5.12	6.45	
n	8	5	10	
df	7	4	9	Σdf=20

Finger Tapping dominant hand, and Seashore Rhythm Test were included because they are six of the seven variables that comprise the Halstead Impairment Index for the adult battery. The seventh variable of the Impairment Index, the Speech Sounds Perception Test, was not included due to the fact that it is not administered to those reading below a fourth grade level. Several of the LD children were below this required level of reading. Trails A and B were the other two variables chosen. These are also included in the adult battery and are considered to provide valuable diagnostic information.

Category Test

Table 10 shows the mean pre and post Category scores and Table 11 shows the mean change scores for all three groups. It can be noted that all groups showed improvement in the desired direction which was to display a reduced number of errors. Tukey's WSD indicated that there were no statistical differences between these pairwise comparisons.

Table 10

Mean Pre and Post Reitan Test Scores for the Treatment, LD Control, and Normal Control Groups

	Treatment		LD Control		Normal Control	
	Pre	Post	Pre	Post	Pre	Post
Category (d)	48.13	37.00	51.20	41.00	36.80	21.70
TPT Total Time (d)	574.50	330.88	526.20	339.20	521.00	458.70
TPT Memory	3.88	5.13	5.20	5.40	5.20	5.10
TPT Localization	3.00	4.38	3.20	5.00	4.30	3.90
Finger Tapping	36.68	34.29	32.43	32.40	38.54	41.54
Seashore Rhythm	22.25	21.38	20.00	20.60	25.90	26.70
Trails A (d)	20.75	15.38	17.60	15.80	14.40	11.00
Trails B (d)	61.25	51.63	49.00	45.20	36.50	29.80

(d) A decreased score is desirable for these individual tests whereas an increase is desirable for the other tests.

Table 11

Tukey Pairwise Test for Mean Change Score Differences in the Category Test Scores

	Treatment	LD Control	Normal Control	
$\bar{x}$	-11.13	-10.20	-15.10	
s	13.51	11.97	11.40	
n	8	8	10	
df	7	4	9	Σdf=20

Tactual Performance Test Total Time

One would hope to see a reduction in the total time required to complete the formboard with each separate hand and both hands together. Table 12 reveals that the mean change score was greater for the Treatment group as compared to the LD Control and that the improvement for the LD Control was greater as compared to the Normal Control; however, these differences were not statistically significant using Tukey's pairwise test.

Table 12

Tukey Pairwise Test for Mean Change Score Differences in the Tactual Performance Test Total Time

	Treatment	LD Control	Normal Control	
$\overline{X}$	-243.63	-187.00	- 62.30	
s	176.97	206.16	275.80	
	8	5	10	
df	7	4	9	Σdf=20

Tactual Performance Test Memory

The student was required to draw from memory as many of the six designs that he had felt while assemblying the formboard blindfolded. Table 10 shows the mean pre and post responses. It can be noted that the Treatment group started at a mean of 3.88 correct responses and improved to a mean of 5.13. The LD Control group, however, started at a higher level with a mean of 5.20 and thus only increased to a mean 5.40. The Normal Controls started off with a mean equal to the LD Control children and then decreased slightly in performance to a mean of 5.10.

The mean change scores appear in Table 13. Tukey's pairwise comparisons revealed no differences between these pairs.

Table 13

Tukey Pairwise Test for Mean Change Score Differences in the Tactual Performance Test Memory

	Treatment	LD Control	Normal Control	
$\bar{x}$	1.25	.20	- .10	
s	1.49	.45	1.20	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

Tactual Performance Test Localization

When the student was drawing from memory the designs of the formboard, he was to place them as best he could in the correct location so that a score of six would have represented a perfect localization score. Table 10 shows that the mean scores increased from 3.00 to 4.38 for the Treatment group and from 3.20 to 5.00 for the LD Control group. The Normal Control group's localization score decreased from 4.30 to 3.90. Table 14 indicates that the mean change score was greater for the LD Control group than the Treatment group. Statistical analysis with Tukey's WSD revealed no differences between the pairs.

Finger Tapping Test

The number of taps with the dominant hand was compared for each pair of groups. Table 10 shows the mean pre and post scores and Table 15 shows the mean change score differences. The Normal Control group was the only group that showed the desirable faster score. There were no statistical differences between the groups using a multiple comparison approach.

Table 14

Tukey Pairwise Test for Mean Change Score Differences in the Tactual Performance Test Localization

	Treatment	LD Control	Normal Control	
$\overline{x}$	1.38	1.80	- .40	
s	2.26	1.10	1.07	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

Table 15

Tukey Pairwise Test for Mean Change Score Differences in the Finger Tapping Test (Dominant Hand)

	Treatment	LD Control	Normal Control	
$\overline{x}$	-2.39	- .03	3.0	
s	4.73	4.12	4.89	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

Seashore Rhythm Test

The student is required to compare 30 pairs of rhythms and indicate if they are alike or different. A score of 30 would be a perfect response. It can be noted in Table 10 and Table 16 that these scores changed minimally from pre to posttesting for all three groups. Statistical significance between the pairs of groups was not obtained.

Table 16

Tukey Pairwise Test for Mean Change Score Differences in the Seashore Rhythm Test

	Treatment	LD Control	Normal Control	
$\bar{x}$	- .88	.60	.80	
s	2.64	2.79	2.39	
n	8	5	10	
df	7	4	9	Σdf=20

Trails A

The score on this test represents the number of seconds required to complete a dot to dot task. Table 10 shows that all three groups reduced their time from pre to posttesting. It can be seen in Table 17 that the treatment group displayed a greater reduction than the other two groups. Analysis with Tukey's WSD did not yield statistical differences between any of the pairs of groups.

Table 17

Tukey Pairwise Test for Mean Change Score Differences in the Trails A Test

	Treatment	LD Control	Normal Control	
$\bar{x}$	-5.38	-1.8	-3.4	
s	8.11	3.19	3.95	
n	8	5	10	
df	7	4	9	Σdf=20

Trails B

A reduction in the number of seconds required to complete this task was desirable. Tables 10 and 18 indicate that all three groups reduced their speed with the Treatment group showing the greatest reduction. Tukey's pairwise comparison test revealed no statistical differences between these pairs of groups.

Table 18

Tukey Pairwise Test for Mean Change Score Differences in the Trails B Test

	Treatment	LD Control	Normal Control	
$\bar{x}$	-9.63	-3.80	-6.70	
s	22.43	18.93	15.81	
n	8	5	10	
df	7	4	9	Σdf=20

Psychoeducational Data

Wide Range Achievement Test (WRAT)

All three sections of the WRAT were administered to all three groups as a measurement of academic gains over the experimental period.

Word recognition. Table 19 shows the mean raw scores in word recognition (reading) for the pre and posttest data. It can be seen that all three groups showed an increase during this specified period of time. The mean change raw score differences are seen in Table 20. Examination of this table indicates that the Normal Control group improved slightly more than the LD Control group and that the Treatment group had a larger difference than either of the control groups. Using Tukey's WSD the Treatment group was found to be statistically different from both of the control groups; however, the LD Control group and Normal Control group were not statistically different from each other.

Table 19

Mean Raw Scores on the Wide Range Achievement Test for the Treatment, LD Control, and Normal Control Students

	Pretest	Posttest
	Treatment (n=8)	
Reading	53.75	66.00
Spelling	32.13	40.00
Arithmetic	28.38	32.50
	LD Control (n=5)	
Reading	51.20	54.40
Spelling	33.40	34.80
Arithmetic	28.80	30.20
	Normal Control (n=10)	
Reading	77.50	81.40
Spelling	51.30	53.00
Arithmetic	38.50	40.20

Table 20

Tukey Pairwise Test for Mean Change Raw Score Differences in Word Recognition on the Wide Range Achievement

	Treatment	LD Control	Normal Control	
$\bar{x}$	12.25	3.20	3.50	
s	4.06	1.48	2.55	
n	8	5	10	
df	7	4	9	Σdf=20

Spelling. The mean raw score for spelling increased from pre to posttesting for all three groups (see Table 19). Table 21 shows that the mean change raw score differences were similar for the two control groups but the Treatment group showed a greater change than either of the other groups. Statistical analysis showed that the pairwise comparisons between the Treatment group and the LD Control group and between the Treatment group and the Normal Control group were statistically significant at the .05 level.

Table 21

Tukey Pairwise Test for Mean Change Raw Score Differences in Spelling on the Wide Range Achievement Test

	Treatment	LD Control	Normal Control	
$\bar{x}$	7.88	1.40	1.70	
s	2.85	2.61	1.77	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

Arithmetic. As with reading and spelling, the mean raw scores for arithmetic also increased from pre to posttesting for all three groups (see Table 19). It can be seen in Table 22 that the Normal Control group increased more than the LD Control group and that the Treatment group increased more than either control group. Using Tukey's multiple comparison test, the Treatment group was found to be statistically different from the LD Control group and from the Normal Control group. The difference between the LD Controls and the Normal Controls did not yield a statistical difference.

Table 22

Tukey Pairwise Test for Mean Change Raw Score Differences in Arithmetic on the Wide Range Achievement Test

	Treatment	LD Control	Normal Control	
$\bar{x}$	4.13	1.40	1.90	
s	2.17	1.14	1.66	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

Spache Diagnostic Reading Scales

The Spache Diagnostic Reading Scale was used to obtain a measurement of comprehension in reading as opposed to word recognition measured by the WRAT. The highest passage level that the child reads with 85% comprehension is the oral or instructional level. The silent or independent level is the highest passage that the child reads with 60% comprehension. The scores obtained are grade level equivalents that do not have raw scores associated with them. Kasdon (1977) puts forth as one of the problems in dealing with gain scores as treating grade scores as equal interval data. Thus, the change scores were ranked and Tukey's WSD was utilized using the obtained ranks. This procedure is deemed appropriate by Iman and Conover (1981).

Table 23 shows the mean change oral reading grade equivalent scores in ranks. It can be noted that the Treatment group improved more than the LD and Normal Control group and that the LD Control showed greater gains than the Normal Control group. Using Tukey's pairwise test, the Treatment group was found to be statistically different from the Normal Control group; however, the differences between the Treatment

Table 23

Mean Change Oral Reading Grade Equivalents in Ranks for Treatment, LD Control, and Normal Control Students

	Treatment	LD Control	Normal Control	
$\bar{x}$	17.00	13.10	7.45	
s	3.67	7.88	4.96	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

and LD Control group as well as between the LD Control and Normal Control group did not reach statistical significance at the .05 level. Examination of Table 24 reveals that the mean change silent reading grade equivalent scores showed the same results as for the oral reading scores.

Table 24

Mean Change Silent Reading Grade Equivalents in Ranks for Treatment, LD Control, and Normal Control Students

	Treatment	LD Control	Normal Control	
$\bar{x}$	17.31	13.10	7.2	
s	4.74	5.00	4.73	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

Bender Gestalt Designs

The Koppitz scoring system (Koppitz, 1963) was utilized in evaluating each student's production of the Bender Gestalt designs. Table 25 shows that the mean error scores decreased for the Treatment

Table 25

Mean Pre and Post Bender Gestalt Errors for the Treatment, LD Control, and Normal Control Groups

	Treatment (n=8)	LD Control (n=5)	Normal Control (n=10)
Pretest	6.00	4.40	2.10
Posttest	3.00	4.40	2.00

group from pre to posttesting; however, the mean error scores for both the control groups remained relatively unchanged. The mean change scores for all groups are depicted in Table 26. Using Tukey's WSD, both the comparison of the Treatment versus the LD Control and the Treatment versus the Normal Control showed statistically significant differences at the .05 level. There was no difference between the two control groups using the pairwise comparison technique.

Table 26

Mean Change Bender Gestalt Scores for Treatment, LD Control, and Normal Control Students

	Treatment	LD Control	Normal Control	
$\overline{X}$	-3.00	0	- .10	
s	2.14	1.22	1.10	
n	8	5	10	
df	7	4	9	$\Sigma df=20$

EEG Data

LD Children versus Normal Children

The EEG data were first examined by looking at the differences between all the LD children and the Normal children with respect to raw power and percentage power. Figure 19 represents the differences between the Normal and LD children before treatment on two EEG measurements (total spectral power and percent power) during baseline, reading, and drawing conditions. The symbols B+, R+, or D+ in a particular box indicate that the LD subjects had larger scores than the Normals for that frequency band at that specific location. The symbols B-, R-, or D- indicate that the Normal children had larger scores than the LD.

In reference to total spectral power, Figure 19 shows that in both the right and left frontal areas the LD subjects have significantly more slow wave activity than the Normals. This same pattern is also noted in the higher frequencies in both frontal areas but not in the intermediate frequencies. The increased power in the higher frequencies for the LD children occurs during all three tasks (baseline, reading, drawing).

Percentage of power for the different frequencies is also represented in Figure 19 for all locations. Note that the LD children have a greater percentage power in the higher frequencies for left hemisphere, central and occipital areas, during the drawing condition. There is also some indication that LD children display greater power in the left frontal and temporal positions during baseline in the 12-15 HZ band or intermediate frequency. The only area where the LD subjects

POWER

LOCATIONS	All	0-4	4-8	8-12	12-16	16-20	20-24	24-28	6-10
C_4T_4									
O_2P_4									
F_8F_4	R+	R+			D+	B+ D+ R+	B+		
F_8T_6									
C_3T_3						D+			
O_1P_3									
F_7F_3		D+				B+			
F_7T_5									

PERCENTAGE

LOCATIONS	0-4	4-8	8-12	12-16	16-20	20-24	24-28	6-10
C_4T_4								
O_2P_4		R-						
F_8F_4				D+				
F_8T_6								
C_3T_3					D+	D+	D+	
O_1P_3				D+	D+	D+	D+	
F_7F_3				B+				
F_7T_5				B+				

FREQUENCY (Hz)

KEY

R - Read
D - Draw
B - Baseline

LD > N = +
LD < N = -

Figure 19. EEG Comparisons for Eight Locations Between 0-28Hz for LD and Normal Children.

showed less percentage of power than the Normal children was in the right hemisphere occipital and parietal area at 4-8 Hz.

Spectral Power as a Function of Task

The spectral power pre and post for the three groups (Treatment, LD Control, and Normal Control) was analyzed via change scores which reportedly allows for a more powerful statistical test than doing sets of t tests pre and post (Guilford & Fruchter, 1973). Figures 20, 21, and 22 display significant changes from pre to post conditions for the EEG of all three groups. Plus scores indicate that the posttest scores were significantly greater than the pretest scores for that group and minus scores indicate the opposite condition.

Figure 20 indicates that for the left hemisphere central location the Normals show an increase in slow activity and intermediate activity for the baseline condition whereas the treated learning disabled group show an increase in higher frequency activity. It can be seen in Figure 21 that during reading the Normal children show an increase in overall power in both the low and high frequencies for the right frontal region. In addition, the Normals also show an increase in the higher frequencies over temporal derivations. The raw power figure for the drawing condition (Figure 22) reveals that in the right occipital region the LD Controls show an increase in the higher frequency. Moreover, in the right frontal region the Normals show an increase in intermediate activity.

LOCATION		All	0-4 (Low)	4-8	8-12	12-16	16-20	20-24	24-28 (High)	6-10
Right Hemisphere	C_4T_4			T-						
	O_2P_4	L-	L-	L-						
	F_8F_4						L+			
	F_8T_6								N-	
Left Hemisphere	C_3T_3	N+		N+		T+ N+	T+ N+	T+	T+	L+
	O_1P_3	N-	N-							
	F_7F_3									
	F_7T_5					N+	L-			

FREQUENCY (Hz)

KEY

T - Treatment
L - LD Control
N - Normal Control

+ = Post > Pre
- = Post < Pre

Figure 20. Directional Comparisons for Pre and Post Training Scores for Baseline Power.

LOCATION		All	0-4	4-8	8-12	12-16	16-20	20-24	24-28	6-10
Right Hemisphere	C_4T_4		T-						L+ N+	N+
	O_2P_4									
	F_8F_4	N+		N+	N+		N+	N+		N+
	F_8T_6					N+		N+	N+	
Left Hemisphere	C_3T_3				T+					N+
	O_1P_3					T-	T-			
	F_7F_3									
	F_7T_5							T-		T+

Low — High

FREQUENCY (Hz)

KEY

T - Treatment
L - LD Control
N - Normal Control

+ = Post > Pre
- = Post < Pre

Figure 21. Directional Comparisons for Pre and Post Training Scores for Reading Power.

LOCATION		All	0-4	4-8	8-12	12-16	16-20	20-24	24-28	6-10
Right Hemisphere	C_4T_4	T+					L+	L+	L+	
	O_2P_4		T-							
	F_8F_4	T+	T+	N+	N+	N+				N+
	F_8T_6					L-				
Left Hemisphere	C_3T_3									
	O_1P_3									
	F_7F_3					N-		T-	N-	
	F_7T_5							L-	L-	

Low — High

FREQUENCY (Hz)

KEY

T - Treatment
L - LD Control
N - Normal Control

+ = Post > Pre
- = Post < Pre

Figure 22. Directional Comparisons for Pre and Post Training Scores for Drawing Power.

Percent Power as a Function of Task

The percent power pre and post for the three conditions was also analyzed utilizing change scores in the same manner as the raw power data. Figures 23, 24, and 25 display statistically significant changes (α = .05, two-tailed) from pre to post conditions. Figure 23 shows that in the baseline condition the LD Controls show an increase in higher and intermediate frequency activity in the right central area whereas the treated LD group only showed an increase in the intermediate frequencies. Secondly, the figure reveals a decrease of very slow activity in both the Treatment and LD Controls in the right central and occipital locations. Third, one can see that there was increased activation of the right temporal regions for Normals.

Figure 24 displays the significant pre and post changes for the reading condition. The Normal subjects show an increase in right temporal activity as well as an increase in right central activity for the higher frequencies. It can be noted that on the one hand the Normal subjects show an increase in right side higher activity but on the other hand the LD Controls show an increase in the intermediate frequencies on the left side.

The last of the percentage figures (Figure 25) shows that the Normals increase in the right hemisphere for the higher frequencies in the draw condition occipitally whereas the treated group shows a decrease in right frontal activity for the higher frequencies. In addition, the Normals show a decrease in the higher frequencies on the left side in the frontal derivations.

LOCATION		0-4	4-8	8-12	12-16	16-20	20-24	24-28	6-10
Right Hemisphere	C_4T_4	L-				L+			N-
	O_2P_4	L- T-	L+ T+	T+	L+	L+	L+	L+	T+
	F_8F_4				L+				
	F_8T_6					N+	N+	N+	
Left Hemisphere	C_3T_3		N-					T+	
	O_1P_3		L+						
	F_7F_3					T-	T-		
	F_7T_5				N+			T+	

Low — High

FREQUENCY (Hz)

KEY

T - Treatment
L - LD Control
N - Normal Control

+ = Post > Pre
- = Post < Pre

Figure 23. Directional Comparisons for Pre and Post Training Scores for Baseline Percentage.

LOCATION		0 -4	4 -8	8 -12	12 -16	16 -20	20 -24	24 -28	6 -10
Right Hemisphere	C_4T_4					L+		L+	
	O_2P_4	N+			N+	T+ N+	N+	N+	
	F_8F_4								
	F_8T_6			T-	N+	N+	N+	N+	T-
Left Hemisphere	C_3T_3	L-		T+	L+	L+			
	O_1P_3	L- N-		L+ N+	L+				N+
	F_7F_3			L+			N-		
	F_7T_5		L+					T-	

Low — FREQUENCY (Hz) — High

KEY

T - Treatment
L - LD Control
N - Normal Control

+ = Post > Pre
- = Post < Pre

Figure 24. Directional Comparisons for Pre and Post Training Scores for Reading Percentage.

LOCATION		0-4	4-8	8-12	12-16	16-20	20-24	24-28	6-10
Right Hemisphere	C_4T_4	N+	N-						
	O_2P_4	N-	T+	N+	N+ L+ T+	N+ T+	N+	N+	N+
	F_8F_4	T+	T-			T-	T-		T-
	F_8T_6								
Left Hemisphere	C_3T_3							L-	
	O_1P_3								N+
	F_7F_3	N+	N-		N-	N-	N-	N-	
	F_7T_5	N+	N-						N-

Low — High

FREQUENCY (Hz)

KEY

T - Treatment
L - LD Control
N - Normal Control

+ = Post > Pre
- = Post < Pre

Figure 25. Directional Comparisons for Pre and Post Training Scores for Drawing Percentage.

CHAPTER IV

DISCUSSION

If a neuropsychological remediation procedure utilized with learning disabled children would have positive results, one would expect to observe changes in the neuropsychological data, psychoeducational data, and EEG data. In addition, it would be expected that the measurements for the Treatment group would diverge from the measurements of the LD Control group and converge toward those of the Normal Control group.

Neuropsychological Data

Wechsler Intelligence Scale for Children-Revised (WISC-R)

The deficit areas of the WISC-R were included in the remediation plan for each student. Thus, one would expect that the overall scores as well as the individual subtest scores would increase for the Treatment group as compared to the Control groups. In examining the Verbal, Performance, and Full Scale scores, all three groups show an increase in IQ points. There is a general trend for the Treatment and LD Control groups to show a greater increase than the Normal Control group but the differences are not statistically significant. In looking at the individual subtests, there was a greater increase in scores for the Treatment group in 8 out of the 12 subtests as compared to the LD Controls but these differences were not statistically significant. One might speculate that since the increases were in the desired direction that a longer period of treatment and/or an increase in the number of subjects might have led to statistical significance. The Bradley et al. study (1979) offers the closest comparison to this study. They devised a remediation technique based on WISC-R subtests and found statistically significant improvement on 8 of the 11 subtests administered. Their treatment group included twelve 10-13 year old learning disabled males and was compared to eight control subjects of comparable age. The remediation sessions were once a week over a six-month period of time. Based upon the number of subjects and remediation time reported by Bradley et al., it does not appear that an increase in either of these two factors would have been the variable that contributed to significant results for Bradley et al. (1979) as compared to the present study.

Similar prescriptive programming studies based on the ITPA rather than the WISC-R also negate the argument for an increase in either time or subjects. Saudargas et al. (1970), with eight treatment subjects and five control subjects, provided treatment of 75-minute sessions five days a week for three months and found minimal changes in the ITPA subtest scores. When Hammill and Larsen (1974) reviewed studies on ITPA remediation, they concluded that the effects of hours of training and length of training period were not significant variables.

Another explanation that must be kept in mind regarding the minimal changes found in standardized test scores after treatment is the intent of these particular assessment measures. Individual ability measurements such as the WISC-R, Stanford-Binet, and ITPA, are constructed and standardized so as to obtain acceptable reliability scores over time. Thus, they undoubtedly include factors that make individual subtest scores resistant to changes other than maturation.

Selz and Reitan Scores

The Selz and Reitan score is a general measure of neuropsychological functioning. It was anticipated that this deficit score would decrease for the Treatment group and remain relatively constant except for some practice and maturation effects for the two Control groups. At post testing the Treatment group showed a noticeable decrease but this was also seen for the learning disabled children that were not treated. The Normals, on the other hand, show very little change in overall scores. The only statistically significant pairwise comparison appeared between the Treatment group and Normal Control group This possibly suggests that the remediation training produced changes in the Treatment group that were significantly different from the changes measured in the Normal students. However, since the LD population in this study was originally different from the Normals in regard to neuropsychological functioning, it is difficult to contribute these findings totally to the training procedure.

The question here is why did the LD Controls improve at a rate almost equal to those who were involved in treatment? One explanation is that learning disabled students who are developmentally delayed would be expected to show greater change in neuropsychological functioning merely as a result of the passage of time than those who did not originally display deficits. This passage of time would be affected by maturity in conjunction with a regression toward the mean. Secondly, and perhaps more important, it must not be forgotten that the LD Controls continued to receive resource assistance in the schools and thus cannot truly represent children receiving no treatment at all. The most definitive finding here is that the normals showed very little improvement in scores; thus, the decrease shown by the two LD groups cannot be solely due to practice effects and/or maturation.

On the eight Reitan variables that were analyzed separately, none of the pairwise comparisons reached statistical significance. However, in six out of the eight measures there was a greater improvement for the Treatment group as compared to the LD Control group. It appears that even though the remediation procedure included activities similar in nature to those areas of deficiency on the Reitan, changes were not noted in post testing with the same measure.

Psychoeducational Data

Wide Range Achievement Test (WRAT)

For all three academic areas on the WRAT (Word Recognition, Spelling, and Arithmetic), the LD Treatment group showed statistically significant gains in comparison to both the LD and Normal controls and these two control groups were not different from each other. Thus, it might appear that the neuropsychological remediation training received by the Treatment group had a positive effect on the students' academic performance as measured by the WRAT. This effect would be considered independent from maturation since Controls in general were significantly below the Treatment group. Once one begins to analyze the reasons for obtaining these raw score gains on the WRAT and not obtaining changes on the WISC-R and Reitan, it does not appear clear as to the critical features of the remediation technique that led to these positive results.

One possibility is that the improved academic scores may be attributed to the portions of the lesson that included academic remediation. In the materials section it was stated that no more than 10 percent of each instructional session would consist of reading, spelling, and arithmetic activities. Thus, if a subject displayed all three (dyslexia, spelling dyspraxia, and dyscalculia) he might receive a total of twelve minutes out of forty of academic remediation. The current literature focuses on the fact that prescriptive-diagnostic teaching is the most parsimonious and effective approach (Wehman, 1977). Thus, the direct training in these three academic areas may have been the critical factor in increased academic performance on the WRAT.

A second factor may have been due to the personality of the therapist and her particular teaching style. Quite recently Wink (1982) has presented the idea that the teacher rather than the remedial procedure is the critical factor in helping LD children. She says that a trusting relationship and the knowledge that a significant adult really cares about the child are both important influences in teaching this type of child. It is the researcher's opinion that a positive bond was present with seven out of the eight treatment subjects based on parent reports and the continued efforts of the students to make contact with the therapist over a two-year period.

Third, one can only speculate as to how much effort is related to the fact that each treated LD child had three different teachers working with him: classroom teacher, LD resource teacher, and the neurotraining therapist of this study. With this many different approaches to teaching academic skills, it would be difficult to definitively state that the improvement in raw scores on the WRAT were related solely to the neuropsychological training.

Spache Diagnostic Reading Scales

For the oral and silent reading levels on this test, the Treatment group showed significantly greater improvement as compared with the Normal students but the treated LD subjects were not found to be different from the LD controls at post testing. It is possible that the greater change seen in both LD groups compared to the Normals was based upon the fact that these two groups were quite different prior to intervention.

Bender Gestalt Designs

Results reveal that the training received in perceptual motor tasks and/or possibly the neuropsychological training in general led to significant improvement in reproducing the Bender Gestalt designs in comparison to no significant changes for the two control groups. Although this appears to be the type of results that would be considered desirable, it must not be forgotten that the literature proports that improved perceptual motor skills do not lead to better academic functioning (Myers and Hammill, 1976). The results do, however, refute Johnson (1974) who says that perceptual motor skills are resistant to training.

EEG Data

LD Children versus Normal Children

The EEG data that involves only the electrophysiological pretesting for all the LD children versus the Normal children provides a descriptive study that is separate from the major experimental study. The results do not always follow the general trends noted in the literature in regard to the amount of raw power or percentage power found in particular locations at specific frequencies. In the LD population, occipital slowing is associated with visual motor tasks (Pavy & Metcalfe, 1965). Hughes (1971), however, reports that temporal slowing rather than occipital is the best delineation for underachievers. Johns'(1977) spectral analysis of a pilot group of LD children supports a 70 percent incidence of excessive posterior slowing (parieto-occipital area). His researcher also showed that 68 percent had slow waves in the frontal regions. The present study showed an increase in slow wave activity in the left and right frontal areas of the LD students as Johns found but these slow waves were not also seen in the parieto-occipital area like many other researchers have found. The LD children in this study also displayed an increase in spectral power for 16-20 Hz which is beta or fast wave activity. The only other researcher who found similar results was Sklar et al. (1973) who found that dyslexics had more beta in the parieto-occipital region during a resting situation. One explanation for this discrepancy is that this truly is a beta effect. It has been noted in this and subsequent research (Shabsin, 1982) that the learning disabled child has great difficulty relaxing during the EEG recordings and as a result one gets increased muscle in the recorded data. These observations have been made via instrumentation that records EMG in excess of 50 uV. It appears that further EEG recordings with LD children might best be obtained after a number of EMG or relaxation training sessions until the child reaches a certain critical value for appropriate relaxation. A third explanation is that the LD children may be experiencing a figure ground problem.

In the percentage power data, the LD subjects show increased activity in the left hemisphere for 12-24 Hz during a drawing condition which is activity in the opposite hemisphere from what would be expected. The fact that the LD children show left hemisphere activation in the higher frequencies suggests the possibility of cross dominance or hemispheric problems which has been proposed and noted also by Johns (1977).

Spectral Power as a Function of Task

In the baseline condition, the Normals in the occipital area showed an increase in slow and intermediate activity and the treated LD children showed an increase in the higher frequencies. One possible explanation for the fact that the LD increase in the higher frequency is that they are failing to habituate to the monotonous baseline task whereas the normal children are demonstrating the habituation one would expect.

It appears that the treatment procedure did not have the desired effect of helping the LD subjects to block alpha during reading as one might expect based on Fuller (1976) and Shabsin (1980). Instead, it appears that the normals showed greater gains even without intervention.

The gains made by the LD Control students in the right occipital region in the higher frequencies are again not in line with expected results. In all likelihood these represent excess muscle or eye movements that have contaiminated the readings (Sklar et al., 1973).

Percent Power as a Function of Task

There are a number of possible explanations for the findings regarding percent power during baseline. The fact that the LD Control subjects showed an increase in higher frequency activity in the right central area can probably be explained by increased EMG. A possible explanation for the treated LD increasing in the intermediate frequencies is that it may represent a decrease in muscle and increased alpha. The activation of the right temporal region for the Normals is most likely due to maturation effects.

The findings in the reading and drawing condition appear to be primarily related to random variation except for one result. One would expect to see the Normal subjects increasing in the higher frequencies for the draw condition and this is indeed what is found. It was anticipated that the treated LD group would show these same effects but this did not occur.

Conclusions and Implications

This study was the first in a series of replication studies devised to investigate the electrophysiological condition of the EEG of LD and Normal children and to explore the efficacy of a remediation technique based on neuropsychological deficits.

The training technique did not appear to affect the neuropsychological or electrophysiological status of the LD after treatment. There does appear to have been an effect on the academic scores on the WRAT. From the present data one cannot effectively delineate the primary variable leading to these significant increases. It is possible that the neuropsychological training was a major factor but since this remediation also included other variables such as academic tutoring and the influence of an additional therapist, one cannot verify a specific cause and effect relationship. Follow-up studies should include groups which receive strict neuropsychological training based solely on the Reitan tests and groups which receive direct academic help only. It might be better if the subject pool was closer to 10 in each group and the groups of equal size. Further studies are necessary before this procedure would be considered appropriate for individual therapy for LD children in the schools or in a private setting.

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